Radiological Health Data

VOLUME IV, NUMBER 7

July 1963

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editiorial Advisors with representatives from the following Federal agencies:

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RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service • Division of Radiological Health

International Numerical Prefixes to be Used in Reporting Data

Effective with this issue, the reporting units used in Radiological Health Data will adhere to the numerical multiple and submultiple prefixes previously established by the International Committee on Weights and Measures and recently adopted by the National Bureau of Standards. These prefixes in combination with the curie unit (see inside back cover) eliminate the need for compound prefixes which appear in millimicrocurie (mμc) and micromicrocurie ($\mu\mu$c).

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in other phases of the environment are being secured through the continuous surveillance of gross beta activity in air and precipitation. The information obtained through this form of surveillance does not by itself permit evaluation of biological effects due to fallout, but it does form the basis of an alerting system and can be used as a rough guide for determining when and where more extensive monitoring of radioactivity in food, milk, and water is desirable.

In this section, March 1963 gross beta concentrations are presented in reports from the Radiation Surveillance Network, the National Air Sampling Network, the Canadian Radioactive Fallout Study Program, and the Mexican Radioactive Fallout Program. Network intercalibration factors, determined by Lockhart and Patterson (*1*), were used in constructing the isogram map (figure 5), which presents data on Canadian and U. S. gross beta radioactivity in air for March. To adjust the data from the two networks to a common baseline, the U. S. data were multiplied by a factor of 1.54, the U. S.-Canadian intercalibration factor suggested by the NRL study.

REFERENCE

(*1*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Washington, D. C. (November 13, 1962); abstracted in December 1962 *Radiological Health Data.*

RADIATION SURVEILLANCE NETWORK March 1963

Division of Radiological Health, Public Health Service

The Radiation Surveillance Network (RSN) comprises 72 sampling stations distributed throughout the United States (see figure 1). Most of these stations are manned by State health department personnel.

Air

Daily 24-hour air samples are collected on a 4-inch diameter, carbon-loaded cellulose dust filter in a high-volume air sampler. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}-Y^{90} known activity source. This determination is usually made about 5 hours after the end of collection to eliminate interference from naturally occurring radon daughters. The network's station operators contribute to a daily national report of radioactivity in air by telephoning their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined meas-

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, MARCH 1963

urement using a thin-window, gas-flow proportional counter. Each filter is counted at least 3 days after the end of the sampling period and re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. From the two counts, which are separated by a 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = \text{constant}$ (*1*).* The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The average fission-product beta concentrations in surface air during March 1963, as determined by laboratory analysis and extrapolated to the time of collection, are given in table 1.

In order to compare U. S. air data and the gross beta concentrations reported by Canada, an adjustment is required. The relationship given by Lockhart and Patterson [1] is

$$\frac{\text{PHS}}{\text{Canada}} = 0.65 \pm 0.048 \text{ (one standard deviation)}$$

which may be written:

$$1.54 \times \text{PHS} \pm 7.4 \text{ percent} = \text{Canada}$$

It was considered more appropriate to adjust the RSN values upward to correspond with Canada's than to adjust the Canadian data downward. This was done in consideration of the higher filter efficiency and lower self-absorption of the Canadian system compared with that of the RSN.[1]

The Canadian air data and the adjusted RSN data have been combined in the map (figure 5) which includes most of the North American continent.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis

* In this expression, A is the activity and T is the time after fission product formation.

[1] See reference (*1*) on page 331.

ABLE 1.—GROSS BETA ACTIVITY OF PARTICULATES IN AIR, RSN, MARCH 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]
Alaska:	Adak	31	7.8	0.23	2.8
	Anchorage	29	9.1	0.19	4.7
	Attu	31	9.6	<0.10	4.9
	Fairbanks	29	7.0	1.0	3.8
	Juneau	28	8.9	0.28	2.9
	Kodiak	31	9.2	0.14	3.4
	Nome	18	3.7	<0.10	1.9
	Point Barrow	24	5.8	0.29	3.8
	St. Paul Island	31	8.0	0.26	3.5
Ariz:	Phoenix	29	15	3.8	9.7
Ark:	Little Rock	29	17	2.1	7.2
Calif:	Berkeley	28	11	1.8	5.0
	Los Angeles	21	13	3.4	6.9
Colo:	Denver	29	24	2.1	9.6
Conn:	Hartford	31	12	0.87	4.7
Del:	Dover	20	12	2.7	7.3
D.C:	Washington	31	15	1.1	5.4
Fla:	Jacksonville	31	11	2.8	5.6
	Miami	29	13	2.6	6.6
Ga:	Atlanta	31	11	1.6	5.3
Guam:	Agana	28	12	0.57	3.4
Hawaii:	Honolulu	31	6.4	1.1	2.9
Idaho:	Boise	31	12	2.5	5.8
Ill:	Springfield	30	8.9	1.3	4.5
Ind:	Indianapolis	30	10	1.0	5.5
Iowa:	Iowa City	29	6.6	1.1	3.5
Kans:	Topeka	31	9.6	0.69	4.1
Ky:	Frankfort	28	10	1.9	5.9
La:	New Orleans	31	11	1.3	5.1
Maine:	Augusta	31	14	2.8	7.4
	Presque Isle	20	8.6	3.6	6.1
Md:	Baltimore	20	9.6	1.0	5.7
	Rockville	17	9.2	0.77	5.4
Mass:	Lawrence	28	11	0.83	4.6
	Winchester	29	23	1.8	8.5
Mich:	Lansing	31	13	3.5	7.0
Minn:	Minneapolis	31	8.8	1.9	4.2
Miss:	Jackson	29	11	0.23	5.6
	Pascagoula	20	13	1.6	4.7
Mo:	Jefferson City	31	8.6	0.97	4.3
Mont:	Helena	31	11	1.5	5.3
Nebr:	Lincoln	17	7.7	1.1	3.6
Nev:	Las Vegas	25	23	3.6	11
N.H:	Concord	21	13	1.7	7.1
N.J:	Trenton	31	11	1.5	5.1
N. Mex:	Santa Fe	31	15	2.0	8.2
N.Y:	Albany	31	9.4	0.96	5.7
	Buffalo	30	8.6	1.6	5.4
	New York	13	9.5	1.4	3.8
N.C:	Gastonia	30	15	2.1	8.5
N. Dak:	Bismarck	31	11	1.8	4.1
Ohio:	Cincinnati	21	8.2	1.5	4.5
	Columbus	30	11	2.0	6.0
	Painesville	24	14	2.8	6.5
Okla:	Oklahoma City	31	12	0.56	4.8
	Ponca City	29	7.8	0.58	2.9
Ore:	Portland	30	16	1.2	6.8
Pa:	Harrisburg	16	9.0	1.8	5.2
P.R:	San Juan	31	6.5	2.4	4.1
R.I:	Providence	31	15	1.1	5.6
S.C:	Columbia	27	9.0	3.0	5.5
S. Dak:	Pierre	31	11	1.0	4.1
Tenn:	Nashville	29	14	3.1	7.5
Tex:	Austin	31	15	2.4	6.9
	El Paso	31	21	3.8	8.4
Utah:	Salt Lake City	31	22	1.9	7.6
Vt:	Barre	31	16	0.76	7.3
Va:	Richmond	31	6.7	1.6	4.3
Wash:	Seattle	31	7.7	0.84	2.7
W. Va:	Charleston	31	9.8	2.7	5.9
Wisc:	Madison	28	12	2.1	5.6
Wyo:	Cheyenne	31	23	1.5	7.5
Network average					5.5

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, RSN, MARCH 1963

Station location		Average concentration (pc/liter)	Total deposition [a] (nc/m²)
Alaska:	Anchorage	2,800	9.3
	Fairbanks	1,000	57
	Juneau	[b]	[b]
Ariz:	Phoenix	[b]	[b]
Ark:	Little Rock	900	140
Calif:	Berkeley	910	78
	Los Angeles	1,300	130
Colo:	Denver	1,800	6.1
Conn:	Hartford	2,300	200
D.C:	Washington	1,300	170
Fla:	Jacksonville	830	55
	Miami	1,300	14
Ga.	Atlanta	<400	<13
Hawaii:	Honolulu	[b]	[b]
Idaho:	Boise	4,300	16
Ill:	Springfield	950	90
Ind:	Indianapolis	1,900	440
Iowa:	Iowa City	2,100	98
Kans:	Topeka	1,700	120
Ky:	Frankfort	1,400	150
La:	New Orleans	1,100	22
Maine:	Augusta	1,000	91
Md.	Baltimore	2,200	66
Mass:	Lawrence	1,000	95
	Winchester	1,700	160
Mich:	Lansing	[b]	[b]
Minn:	Minneapolis	2,400	84
Miss:	Jackson	1,200	46
Mo:	Jefferson City	1,300	140
Mont:	Helena	3,800	7.6
Nebr:	Lincoln	2,300	99
Nev:	Las Vegas	[b]	[b]
N.J:	Trenton	2,400	60
N. Mex:	Santa Fe	4,200	60
N.Y:	Albany	860	24
	Buffalo	[b]	33
N.C:	Gastonia	710	110
N. Dak:	Bismarck	2,300	3.9
Ohio:	Columbus	1,800	280
	Painesville	2,500	190
Okla:	Oklahoma City	1,600	30
	Ponca City	1,700	100
Ore:	Portland	1,400	110
Pa:	Harrisburg	1,300	36
P.R:	San Juan	1,200	110
R.I:	Providence	1,600	140
S.C:	Columbia	910	78
S. Dak:	Pierre	1,600	13
Tenn:	Nashville	1,700	200
Tex:	Austin	5,800	7.2
	El Paso	[b]	[b]
Utah:	Salt Lake City	1,900	120
Vt:	Barre	1,400	97
Va:	Richmond	1,000	110
Wash:	Seattle	1,200	110
W. Va:	Charleston	2,300	280
Wisc:	Madison	2,400	140
Wyo:	Cheyenne	1,800	24

[a] Precipitation (mm) $= \frac{\text{nc/m}^2}{\text{pc/liter}} \times 1000$

[b] No evaporated sample received.

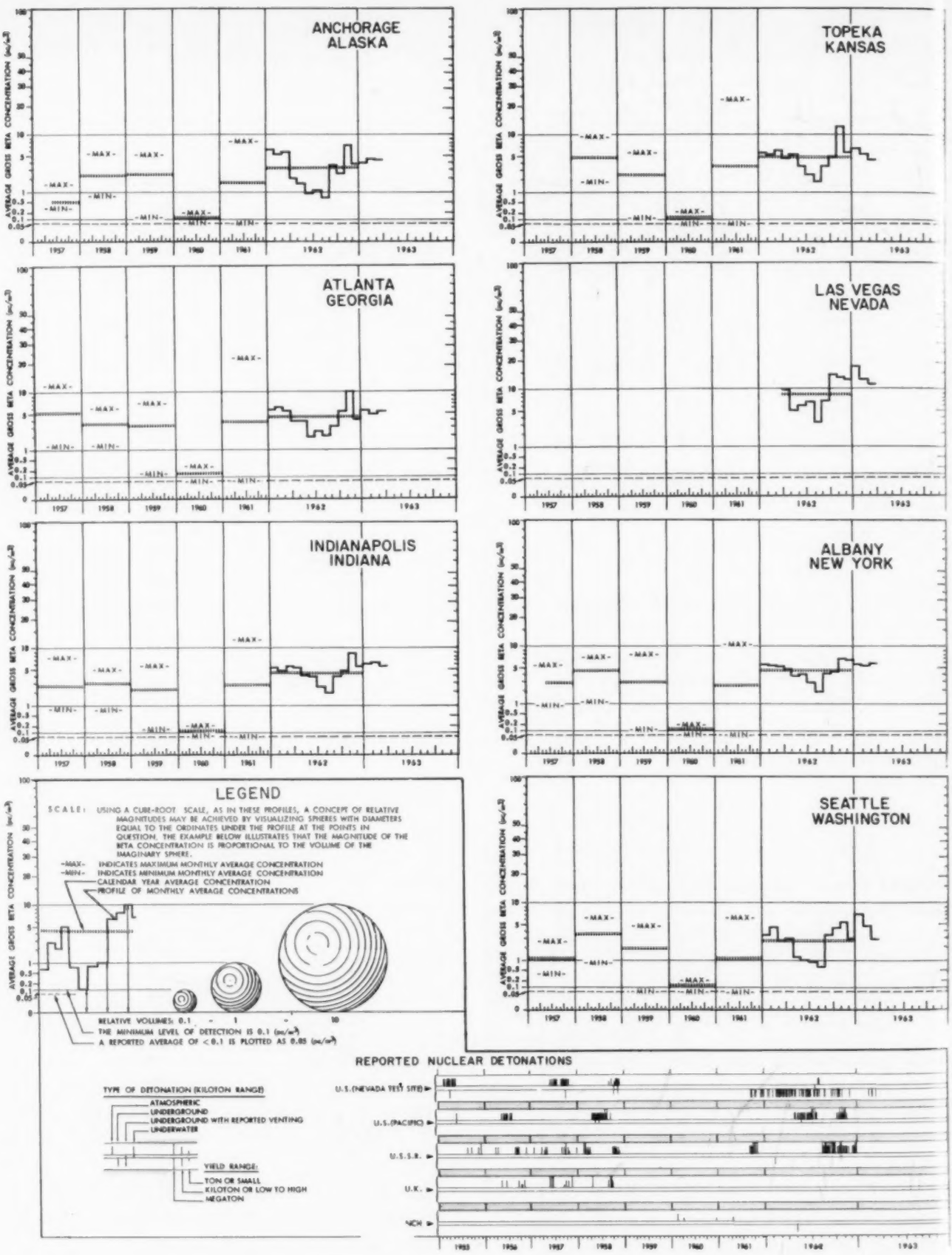


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957-MARCH 1963

sing funnels with collection areas of 0.4 square meters. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory to be counted by the same method used for analyzing the air samples, including extrapolation to the time of collection. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made. March 1963 averages of gross beta activity in precipitation, expressed in picocuries per liter (pc/liter) and nanocuries per square meter (nc/m^2), are presented in table 2.

Profiles

The profiles of the monthly average fission product beta activity in airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in *RHD*, July 1961. The profiles of 7 stations, updated through March 1963, are shown in figure 2.

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physics Review*, *37*:1318-30 (June 1948).

(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington 25, D. C. (Distribution by official request).

NATIONAL AIR SAMPLING NETWORK
First Quarter 1963

Division of Air Pollution, Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, FIRST QUARTER 196

[Concentrations in pc/m³]

Station location		Number of samples	Minimum	Maximum	Average
Ala:	Birmingham	6	0.8	15.6	8.9
	Huntsville	6	1.0	16.6	8.1
	Montgomery	6	1.9	14.3	8.9
Alaska:	Anchorage	6	0.8	16.6	7.2
	Pt. Woronzof*	7	1.4	16.5	7.8
Ariz:	Grand Canyon Pk.*	7	5.7	47.2	18.7
	Maricopa Co.*	6	13.6	26.5	19.8
	Phoenix	6	11.3	26.7	18.3
	Tucson	6	7.2	23.4	15.3
Ark:	Little Rock	5	6.2	13.6	10.8
	Montgomery Co.*	5	4.7	15.3	8.9
Calif:	Berkeley	3	2.8	24.4	11.2
	Glendale	5	10.1	17.6	13.1
	Humboldt Co.*	7	2.7	24.6	6.7
	Long Beach	6	7.1	24.6	15.7
	Los Angeles	6	7.3	30.0	12.9
	Monterey	3	4.4	5.1	4.7
	Oakland	6	3.7	27.5	9.9
	San Bernardino	6	12.0	25.2	17.6
	San Diego	6	5.8	29.7	14.5
	San Francisco	6	4.2	25.6	9.5
	San Jose	6	4.3	29.6	10.1
	Santa Barbara	5	3.1	31.4	14.3
	Stockton	6	3.6	11.0	6.2
Colo:	Denver	5	6.4	16.6	9.2
	Montezuma Co.*	7	3.8	27.6	15.4
	Pueblo	6	8.0	22.4	13.2
Conn:	Hartford	3	2.8	7.1	5.3
	New Britain	5	3.6	11.0	7.6
	New Haven	6	3.8	11.7	7.9
	Norwich	6	3.0	14.2	8.5
	Waterbury	6	3.2	8.1	5.6
Del:	Kent Co.*	4	1.7	7.5	5.0
	Wilmington	5	2.6	9.7	6.8
D. C:	Washington	6	2.4	11.2	6.6
Fla:	Florida Keys*	6	5.3	16.3	11.2
	Miami	6	4.7	17.1	11.4
	Orlando	5	5.1	18.7	10.6
	St. Petersburg	6	4.2	11.5	7.9
	Tampa	5	4.8	12.1	8.0
Ga:	Atlanta	6	0.5	16.0	7.9
	Augusta	6	4.2	15.1	9.3
	Savannah	6	4.0	12.1	8.2
Hawaii:	Honolulu	6	3.3	12.4	6.9
	Kahaluu*	7	4.0	12.8	6.8
Idaho:	Boise	6	6.5	26.5	15.1
	Butte Co.*	7	7.2	22.9	13.1
Ill:	Chicago	4	2.6	6.3	5.7
	East St. Louis	6	6.4	11.5	8.9
	Joliet	6	4.2	9.6	7.6
	North Chicago	4	5.0	12.4	9.2
	Rockford	6	3.6	9.5	7.6
Ind:	East Chicago	4	3.3	16.8	8.4
	Hammond	6	4.9	9.1	7.3
	Indianapolis	4	3.2	12.2	7.1
	Muncie	6	4.4	9.7	7.8
	Parke Co.*	7	7.5	16.5	11.3
	South Bend	6	5.1	16.5	8.9
	Terre Haute	4	5.9	10.9	8.3
Iowa:	Cedar Rapids	6	4.2	12.8	8.3
	Davenport	6	4.9	15.5	9.6
	Delaware Co.*	7	2.6	9.2	6.7
	Des Moines	6	2.2	8.7	4.6
Kans:	Topeka	6	3.2	10.3	7.5
	Wichita	6	3.2	17.0	9.9
Ky:	Lexington	6	2.8	12.4	9.0
	Louisville	5	4.7	10.2	7.4
La:	New Orleans	6	1.4	14.7	8.1
	Shreveport	6	5.3	17.0	8.7
Maine:	Acadia Nat. Park*	6	2.2	9.4	6.2
	Portland	6	3.3	11.8	8.5
Md:	Baltimore	6	1.9	8.6	4.9
	Calvert Co.*	8	2.5	17.0	8.1
	Cumberland	6	5.5	8.1	6.9
Mass:	Boston	4	2.8	7.5	5.6
	Lowell	6	3.9	16.7	10.3
	Worcester	6	2.4	10.5	7.4
Mich:	Dearborn	6	5.4	10.8	8.1
	Detroit	6	4.0	8.9	5.8
	Flint	4	4.5	6.0	4.9
	Grand Rapids	4	4.3	7.3	5.6
	Jackson	6	6.5	17.3	9.8
	Muskegon	5	4.8	10.5	7.2
Minn:	Duluth	6	3.2	8.3	6.0
	Minneapolis	6	1.5	8.2	5.9
	St. Paul	6	2.8	9.3	6.4
Miss:	Jackson	5	2.5	18.4	10.8
	Jackson Co.*	4	1.0	17.9	9.4
Mo:	Kansas City	6	3.7	17.2	9.5
	Shannon Co.*	6	5.5	19.6	12.0
	St. Louis	6	4.9	12.4	9.0
Mont:	Glacier Nat. Pk.*	3	2.5	9.5	5.5
	Helena	6	4.6	22.0	10.1
Nebr:	Omaha	6	1.7	13.7	8.5
	Thomas Co.*	6	5.8	20.4	11.3
Nev:	Las Vegas	6	13.4	27.5	19
	Reno	5	5.3	18.6	11
	White Pine Co.*	7	7.0	36.5	16
N.H:	Coos Co.*	4	5.9	15.3	9
N.J:	Atlantic City	5	5.5	11.0	7
	Bayonne	6	2.7	9.8	5
	Hamilton	5	4.0	9.9	6
	Jersey City	4	2.5	11.4	7
	Newark	6	2.2	10.4	5
	Paterson	6	2.1	9.3	5
N.M:	Albuquerque	6	10.8	25.6	15
	Colfax Co.*	7	7.7	38.4	21
N.Y:	Cape Vincent	6	5.3	20.3	9
	Glen Cove*	2	5.1	5.9	5
	Massena	6	3.2	8.7	6
	New York City	6	6.9	13.0	9
	Niagara Falls	5	5.7	11.0	8
	Rochester	5	3.8	8.4	6
	Troy	5	3.9	14.4	7
N.C:	Cape Hatteras	6	4.4	14.8	8
	Charlotte	6	5.3	17.9	9
	Durham	6	2.1	16.2	8
	Greensboro	6	0.6	17.4	9
	Raleigh	6	1.7	9.4	6
N. Dak:	Bismarck	6	4.8	11.5	7.7
	Ward Co.*	6	2.7	15.4	7.8
Ohio:	Akron	6	4.7	9.0	6.5
	Canton	6	4.6	8.7	6.9
	Cincinnati	6	5.1	9.7	7.2
	Cleveland	6	4.7	16.0	8.6
	Columbus	6	5.1	10.5	7.1
	Dayton	6	5.3	8.8	7.2
	Hamilton	6	5.0	10.0	7.9
	Toledo	6	5.3	10.9	7.6
	Youngstown	6	4.8	10.6	7.3
Okla:	Cherokee Co.*	7	4.6	16.2	9.3
	Oklahoma City	4	3.6	22.5	10.7
	Tulsa	5	5.7	18.4	12.8
Ore:	Curry Co.*	5	2.6	10.8	6.2
	Eugene	5	2.4	24.1	8.9
	Medford	5	2.0	6.9	4.7
	Portland	5	2.8	22.0	8.8
Pa:	Allentown	7	2.4	10.0	6.1
	Altoona	2	4.8	10.8	7.8
	Bethelehem	6	1.3	13.4	8.6
	Clarion Co.*	5	3.9	8.0	6.1
	Erie	6	4.9	10.9	8.3
	Johnstown	5	2.7	10.5	6.6
	Philadelphia	5	1.5	12.8	6.7
	Pittsburgh	6	5.0	9.5	7.1
	Scranton	6	3.3	9.2	6.0
	York	6	2.2	10.4	5.9
P.R:	Loquillo Mountains*	3	1.8	4.7	3.7
	San Juan	5	0.6	7.6	4.9
R.I:	East Providence	6	3.3	11.4	7.4
	Providence	6	3.0	9.4	6.8
	Washington Co.*	7	6.5	11.7	9.2
S.C:	Charleston	6	4.1	23.8	10.6
	Columbia	6	1.3	13.0	7.8
	Richland Co.*	7	7.8	25.6	13.9
S. Dak:	Black Hills Forest*	7	7.7	25.1	13.0
	Sioux Falls	5	3.3	10.5	7.4
Tenn:	Chattanooga	6	8.0	15.2	11.9
	Knoxville	5	2.9	14.1	7.5
	Memphis	6	5.2	17.5	11.6
	Nashville	6	4.3	15.4	10.2
Texas:	Aransas	6	3.9	17.5	8.8
	Austin	6	6.2	17.6	11.7
	Beaumont	3	6.9	11.7	9.2
	Dallas	5	5.2	11.7	8.0
	Galveston	6	5.5	13.6	8.9
	Houston	5	3.1	14.7	8.1
	Odessa	6	9.4	19.0	13.2
	San Antonio	6	4.4	21.1	11.3
	Tyler	6	3.9	14.2	9.8
Utah:	Salt Lake City	6	5.0	19.8	13.8
Vt:	Burlington	6	3.3	13.6	8.6
	Orange Co.*	7	1.9	16.7	8.6
Va:	Hampton	6	2.8	8.0	5.7
	Lynchburg	6	1.6	14.4	7.9
	Norfolk	6	3.8	15.3	7.6
	Portsmouth	6	3.1	13.1	8.4
	Richmond	6	4.4	13.1	8.4
	Roanoke	4	8.8	16.8	11.5
	Shenandoah Nat. Pk.*	7	4.6	20.3	9.3
Wash:	Clallam Co.*	3	2.5	2.6	2.6
	Seattle	6	2.0	23.0	6.5
	Spokane	5	2.3	17.2	9.0
W. Va:	Charleston	6	6.1	11.4	9.0
	Wheeling	6	4.9	13.7	7.9
Wisc:	Door Co.*	6	2.8	10.7	7.2
	Kenosha	6	4.6	9.4	7.3
	Madison	6	4.1	10.2	7.3
	Milwaukee	6	3.5	9.7	6.5
Wyo:	Cheyenne	6	9.3	20.8	13.9
	Yellowstone Pk.*	7	4.6	19.4	12.5

*Nonurban Station.

953. The NASN analyzes air samples for the otal quantity of suspended particulate matter, enzene-soluble organic matter, and gross beta adioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of rends in levels of pollution with respect to ime, location, population density, climate, and ther factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. First quarter 1963 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the first quarter of 1963 are shown in table 4.

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, NASN, FIRST QUARTER 1963

Station		January		February		March	
		pc/liter	nc/m^2	pc/liter	nc/m^2	pc/liter	nc/m^2
Alabama:	Montgomery	472	79.4	1080	73.1	1220	51.7
California:	Santa Maria			350	22.1		
Colorado:	Grand Junction	525	23.1				
Florida:	Tampa			270	15.9		
Louisiana:	Lake Charles	554	56.5	800	84.0		
Maine:	Caribou	865	54.5	550	44.3	890	55.4
Massachusetts:	Nantucket	1852	169.6	1030	113.5	1020	119.4
Michigan	Sault Ste. Marie					2070	107.9
Missouri:	Columbia					1040	85.2
New York:	Albany	1920	105.8			3140	153.0
North Carolina:	Cape Hatteras	1239	120.8	920	158.8	1130	44.8
Ohio:	Cincinnati (Airport)	1583	60.5			1420	273.4
	Cincinnati (Gest St.)	2612	115.2			2360	440.5
Pennsylvania:	Philadelphia	2487	134.6	1010	53.3	1190	117.4
South Carolina:	Charleston	862	58.2	470	65.9		
	Greenville	739	72.1	1380	109.1	410	99.2
Tennessee:	Nashville			1200	65.6	700	126.9
Virginia	Sterling			1260	54.1	980	105.6
Washington:	Tatoosh			1500	170.6	1360	111.7

CANADIAN RADIOACTIVE FALLOUT STUDY PROGRAM, March 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program (RFSP), the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 4) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1-5*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is removed from each filter and counted with a thin-end-windo Geiger flow counter system, calibrated with

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, RFSP, MARCH 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Ave age
Calgary	31	22.0	3.5	9.0
Coral Harbour	27	13.9	2.9	8.1
Edmonton	31	13.9	3.0	6.4
Ft. Churchill	30	10.4	4.5	7.0
Ft. William	31	17.2	4.6	10.4
Fredericton	31	21.0	3.7	12.6
Goose Bay	31	12.1	0.4	8.4
Inuvik	31	17.7	6.2	10.7
Montreal	30	18.8	4.4	11.6
Moosonee	30	19.0	7.5	12.2
Ottawa	30	19.0	5.0	11.8
Quebec City	30	26.0	4.7	13.2
Regina	31	19.0	2.7	8.4
Resolute	13	10.0	4.8	7.9
Saskatoon	31	16.8	3.3	8.2
Sault St. Marie	30	16.9	7.5	10.8
Shearwater	30	24.0	2.1	12.2
Torbay	29	19.0	1.6	8.1
Toronto	31	17.0	1.1	9.9
Vancouver	31	15.6	1.7	6.5
Whitehorse	31	19.4	0.8	9.4
Windsor	30	16.2	3.9	10.5
Winnipeg	31	12.7	3.9	8.6
Yellowknife	31	22.2	5.9	9.9
Average				9.5

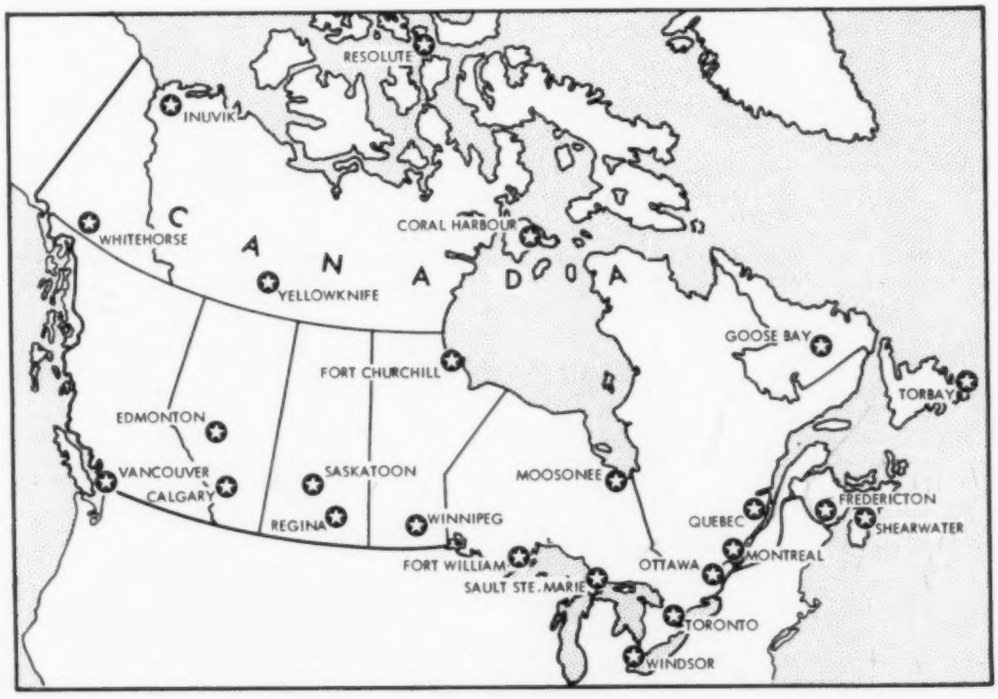
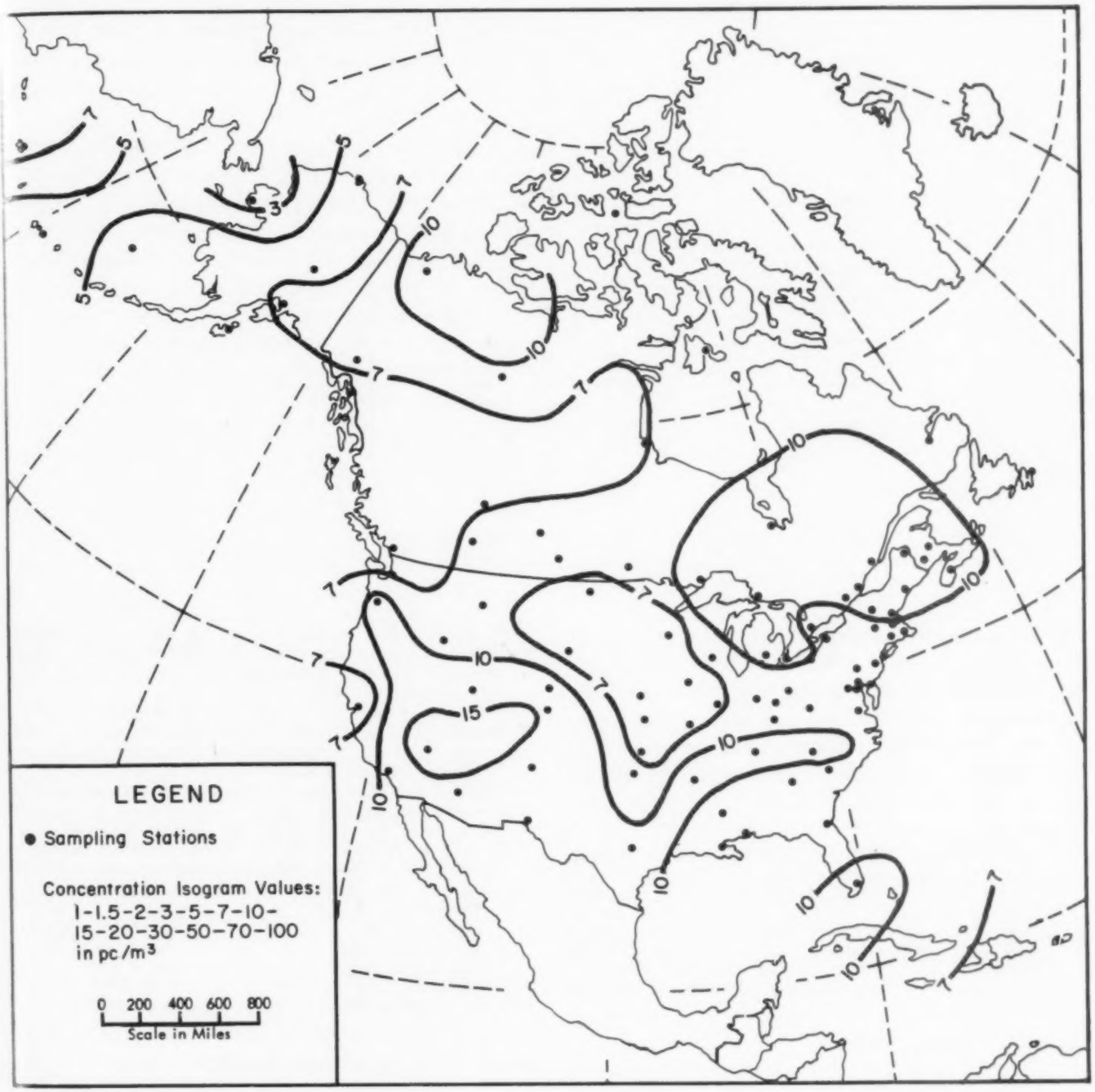


FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

FIGURE 5.—AIRBORNE GROSS BETA CONCENTRATION CONTOURS FOR CANADA AND THE U. S., MARCH 1963



Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to allow for the presence of natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for March 1963 are given in table 5 and presented in conjunction with U. S. adjusted air data by the isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measure-

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, RFSP, MARCH 1963

Station location	Total beta activity		Deposition of specific radionuclides for selected samples [a, b] (nc/m^3)				
	pc/liter	nc/m^2	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}
Calgary	2,012	29.2	2.46	0.23	4.77	0.47	0.19
Coral Harbour	[c]	24.6					
Edmonton	3,864	62.1					
Fredericton	1,466	128.8					
Ft. Churchill	1,941	23.1					
Ft. William	1,536	66.0					
Goose Bay	1,353	95.7					
Inuvik	1,114	25.1					
Montreal	2,679	233.3	17.7	1.42	24.4	2.10	0.90
Moosonee	3,284	79.0					
Ottawa	2,887	160.2					
Quebec	1,786	140.8					
Regina	3,983	20.6					
Resolute	3,907	101.2					
Saskatoon	3,300	53.0					
Sault St. Marie	2,136	147.2					
Shearwater	1,894	105.5					
Torbay	894	51.0					
Toronto	2,357	163.0					
Vancouver	3,186	236.1	16.5	1.38	32.2	2.85	0.83
Whitehorse	802	20.4					
Windsor	2,552	201.1					
Winnipeg	1,584	30.0	2.80	0.22	3.73	0.24	0.21
Yellowknife	1,909	13.9					
Average	2,279	92.1					

[a] All values corrected for decay back to end of collection month.
[b] Values for strontium-90, cesium-137, and zirconium do not include the activities of their daughter isotopes, yttrium-90, barium-137, and niobium-95.
[c] Trace precipitation.

ments on material collected in special polythene-lined rainfall pots. After transfer of the water to the sampling container, the polythene liner is removed, packed with the sample, and sent to the laboratory. March precipitation data for Canada, including some radiochemical analyses, are shown in table 6.

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(*1*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3,* Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4,* Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5,* Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11,* Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5* Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21,* Department of National Health and Welfare, Ottawa, Canada (August 1962).

Recent coverage in *Radiological Health Data:*

Period	*Issue*
October 1962	*February 1963*
November 1962	*March 1963*
December 1962	*April 1963*
January 1963	*May 1963*
February 1963	*June 1963*

MEXICAN RADIOACTIVE FALLOUT PROGRAM
March 1963

Radiological Protection Program
National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comisíon Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation due to fallout from nuclear tests.

Prior to the establishment of the network, two pilot sampling stations were set up in Mexico City and San Luis Potosí, to aid in the selection of equipment and sampling sites. Since April 1962 the network has been expanded to twelve stations, eleven of which were in operation by the end of March 1963 (see figure 6).

Seven of the twelve stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the RPP operate the station at Mexico City, while the other four stations are manned by members of the Centro de Previsión del Golfo de Mexico, the Chemistry Department of the University of Merida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

FIGURE 6.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6″ x 8″, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via airmail to the Laboratorio de Desechos Radiactivos, CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughters natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum, and average fission product beta concentration in surface air during March 1963 are presented in table 7.

TABLE 7.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, MARCH 1963

[Concentration in pc/m³]

Station	Number	Maximum	Minimum	Average
Acapulco	7	7.75	3.81	5.19
Ciudad Juárez	11	66.81	4.12	18.19
Ensenada	4	12.03	4.46	9.19
Guadalajara	7	6.73	3.23	4.81
La Paz	17	11.84	4.34	7.01
Mérida	12	10.86	3.34	6.04
México, D. F.*	21	9.90	1.87	5.04
San Luis Potosí	13	14.30	2.45	7.58
Torreón	13	27.05	4.15	11.33
Tuxtla Gutiérrez	9	9.90	3.13	6.83
Veracruz	20	14.61	3.19	7.42

* Mexico City

Fission Product Gamma Activity in Airborne Particulates

In a recent proposal (*1*) submitted by the World Meteorological Organization (WMO), after consultation with the United Nations Scientific Committee on the effects of Atomic Radiation, the concept of air monitoring for fission products by gamma rather than beta counting was advanced. The method involves the simultaneous measurement of total gamma and of gamma over 1 Mev. Some theoretical advantages are cited for the use of gross gamma assay of air filters rather than the more customary gross beta measurement in Mr. Collins' report below.

The Health and Safety Laboratory has completed preliminary studies of gamma monitoring and has converted the 80th Meridian Network from beta to gamma measurement of each filter. These data will be reported on a monthly basis in *Radiological Health Data.*

THE 80TH MERIDIAN NETWORK
January 1963

William R. Collins, Jr.[1]

As of January 1, 1963, the Naval Research Laboratory (NRL) has withdrawn from the 80th Meridian air sampling program [2] to concentrate on certain research projects. Because of the value of the radioactivity in air measurements that the NRL had been making, the program has been continued by the Health and Safety Laboratory (HASL). The station locations are shown in figure 1.

Certain modifications have been made in the NRL system.[3] These include:

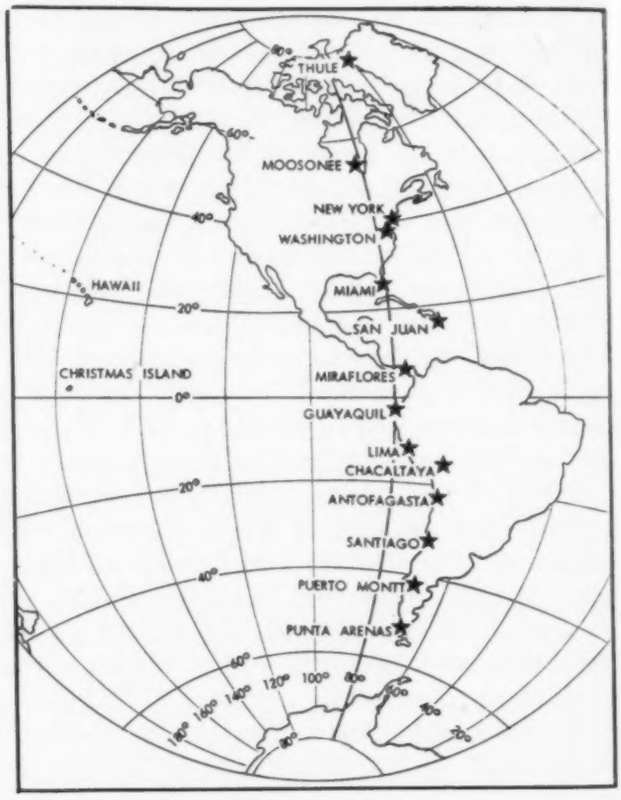

FIGURE 1.—ATMOSPHERIC RADIOACTIVITY SAMPLING STATIONS NEAR THE 80TH MERIDIAN (WEST)

1. Determination of gamma activity rather than beta activity for initial semi-quantitative measurements. This will be treated in detail below.
2. Substitution of Microsorban filters for the type 6 cellulose-asbestos paper previously used. Air volume has been increased from about 1200 to about 1300 m³. Experiments at NRL and at HASL have shown the two filters to be essentially equivalent. HASL considers Microsorban to be simpler to handle in the radiochemical analyses.
3. Addition of monthly ion exchange collectors to determine fallout deposition and to allow correlation of the two types of measurement.

[1] Mr. Collins is a staff member of the U. S. Atomic Energy Commission's Health and Safety Laboratory in New York City.

[2] Monthly gross beta averages and profiles covering the period from November 1959 through December 1962 were reported monthly in *Radiological Health Data*—April 1960-April 1963. Results of the radiochemical analyses of the air filters for the calendar year 1960 and 1961 were presented in *RHD*—March 1962 and February 1963, respectively.

[3] These changes were effected on March 1 at the Northern Hemisphere stations and on April 1 at the stations in the Southern Hemisphere.

4. Setting dates for the start of the air filter sampling, as the 1st, 8th, 15th, and 22nd of each month. The new collection periods allow compositing of the individual air filter samples by months, to correspond with the deposition collector.

The most meaningful data from the 80th Meridian air sampling network are the results of the radiochemical analyses of the filters for individual radionuclides, such as strontium-90, cesium-137, and cerium-144. The chemical analyses, however, are quite laborious and lengthy; thus, there is frequently a lag of several months between the sampling period and the time at which results become available.

In an attempt to obtain more rapid semi-quantitative results, the Naval Research Laboratory measured the total beta activity of the filters at a fixed time after sampling. This type of measurement gives good information on the arrival of airborne radioactivity and is the basis of a number of sampling networks in the United States and other countries. The single total beta measurement does not give information, however, on whether the radioactivity is of recent origin or is older material being collected at high concentrations because of meteorological factors. In addition, the standardization of counters for measuring total beta activity is quite difficult since the mixture of radionuclides emits beta particles with a wide range of energies.

In considering a suitable replacement for total beta activity measurements, the United Nations Scientific Committee on the Effects of Atomic Radiation has recommended the use of gamma activity measurements (*1*). With relatively simple gamma measuring equipment it is possible to measure both the total of all gamma rays from the sample and the fraction of those gamma rays having an energy above one million electron volts (>1 Mev). This latter gamma radiation is indicative of fresh fission products, particularly barium-lanthanum-140. With the two measurements it is possible to obtain the information on arrival of airborne activity and, in addition, to determine whether or not it contains fresh fission products.

The Health and Safety Laboratory has adopted this procedure for the rapid semi-quantitative measurement of the 80th Meridian filters. Samples received at HASL are gamma counted on an 8″ x 4″ (20 x 10 cm) sodium iodide crystal, obtaining both total gamma activity and the fraction of the gamma activity with energies above 1 Mev. In addition, the filters, after gamma measurement of the weekly samples, will be grouped by months and subjected to radiochemical analysis.

One problem that remains is the comparison of data produced by the new system with earlier data produced by total beta counting. Since both of these are semi-quantitative methods it is not necessary to have an exact factor for converting one to the other and, in fact, this is not possible. Two quantities are needed for conversion. One is the factor for the counter efficiency which is the number of gamma counts per gamma photon. This factor has been measured for a number of gamma-emitting fission products and an average value of 0.35 has been adopted for the particular counting conditions used. The measured factors for a number of nuclides are given in table 1.

The second factor is the number of beta disintegrations per minute associated with the emission of a particular number of gamma photons per minute. This factor has been calculated for mixed fission products of different ages from the known abundances and radioactive properties of the individual fission products. These data are plotted in figure 2. It is evident that, for fission products ranging from 10 days to 4 months in age, the factor is about 1.5. Beyond that age the factor is variable, but if 3 is accepted, the error will be less than 50 percent.

It is possible to decide whether or not the average age of mixed fission products is less than 4 months. Measurements on the fission products in 93-percent enriched uranium-235, irradiated with thermal neutrons, were made over an extended period. Gamma over 1 Mev

TABLE 1.—PHOTON EFFICIENCIES FOR VARIOUS FISSION PRODUCTS

Radionuclide	Efficiency (counts per photon)
Ba^{140} - La^{140}	0.334
Cs^{137} - Ba^{137m}	0.439
I^{131}	0.359
Ce^{144} - Pr^{144}	0.301
Zr^{95} - Nb^{95}	0.316
Mean	0.350

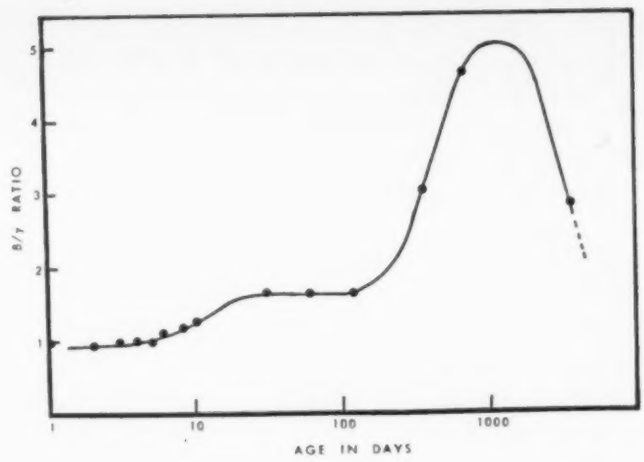

FIGURE 2.—BETA TO GAMMA RATIO AS A FUNCTION OF AGE OF FISSION PRODUCTS

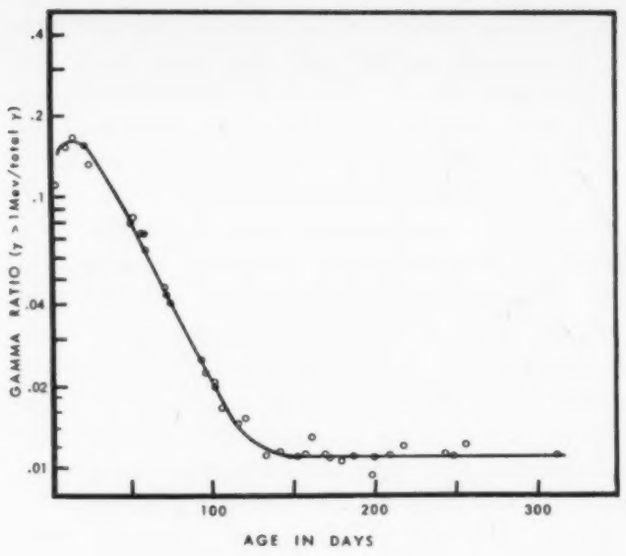

FIGURE 3.—FRACTION OF GAMMAS OVER 1 MEV AS A FUNCTION OF AGE OF FISSION PRODUCTS

and total gamma were measured, and the ratio of the resulting count rates is shown in figure 3. Fission products having an average age greater than 4 months show a fairly constant gamma ratio of 0.011, and younger fission products show a higher ratio.

In practice, the first step is to measure both the total gamma activity and the gamma activity above 1 Mev. From the ratio of the two measurements, the average age is determined. The total gamma count is then corrected for counter efficiency to give total gamma photons per minute. This is then multiplied by 1.5 for young fission products or 3 for older fission products to give an estimate of total beta activity.[4]

Table 2 lists a few comparative results for filters run at NRL for total beta activity and at HASL for total gamma activity with subsequent estimate of beta activity. The agreement between the two sets of values is better than expected and may not be typical.

It should be emphasized that the total beta activity obtained in this way is an estimate. It will be included in the 80th Meridian reports only to allow comparison with earlier measurements. The total gamma should be just as meaningful as total beta, and the most significant data will still be that based on radiochemical analysis.

The addition of ion exchange fallout collectors to the 80th Meridian Network sampling is intended to allow radiochemical comparison between airborne radioactivity and fallout deposi-

[4] A further conversion to picocuries is made by dividing by 2.22 dpm/pc.

TABLE 2.—COMPARISON OF ESTIMATED AND MEASURED BETA ACTIVITIES

Sampling site	Sampling date	Calculated		Measured	
		Beta dpm (HASL)	Reference date (1963)	Beta dpm (NRL)	Reference date (1963)
Miraflores, Panama Canal Zone	Dec 24-31, 1962	79,800	Jan. 18	51,800	Jan. 25
Mauna Loa, Hawaii	Dec. 17-22, 1962	40,400	Jan. 18	40,000	Jan. 25
Washington, D. C.	Jan. 1963	116,000	Mar. 11	114,400	Mar. 26
		115,000	Mar. 11	85,000	Mar. 26
		163,000	Mar. 11	172,900	Mar. 26
San Juan, Puerto Rico	Nov. 26 - Dec. 12, 1962	42,600	Mar. 15	41,800	Mar. 21
	Dec. 3-13, 1962	49,500	Mar. 15	48,400	Mar. 21
	Dec. 17-24, 1962	86,900	Mar. 15	94,100	Mar. 21
	Dec. 24-31, 1962	44,200	Mar. 15	47,700	Mar. 21

TABLE 3.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, JANUARY 1963

Sampling station	Sampling period dates—noon to noon	Gamma activity (photons/min/m³)			Estimated total beta activity (pc/m³)
		Filter	Average for month	$\gamma > 1$ Mev to total γ ratio	
Thule, Greenland	1-8	6.16		0.035	4.2
76° 36′N	8-15	11.8		0.032	8.0
68° 35′W	15-22	14.2		0.047	9.6
Elev. - 259 meters	22-2/1	16.6	12.2	0.024	11.2
Moosonee, Canada	1-8	9.34		0.037	6.3
51° 16′N	8-15	4.05		0.033	2.7
80° 39′W	15-22	8.40		0.025	5.7
Elev. - 10 meters	22-2/1	8.14	7.50	0.026	5.5
New York, New York[a]					
40° 48′N					
73° 58′W					
Elev. - 38 meters					
Washington, D. C.	1-8	13.0		0.030	8.8
38° 58′N	8-15	8.20		0.043	5.5
77° 25′W	15-22	14.5		0.040	9.8
Elev. - 76 meters	22-2/1	23.8	14.9	0.021	16.1
Miami, Florida	1-7	18.9		0.025	12.8
25° 49′N	7-14	18.5		0.040	12.5
80° 17′W	14-21	6.54		0.026	4.4
Elev. - 4 meters	21-31	16.1	15.0	0.029	10.9
Mauna Loa, Hawaii	1-8	6.02		0.028	4.1
19° 28′N	8-15	7.73		0.030	5.2
155° 36′W	22-2/1	10.6	8.33	0.021	7.2
Elev. - 3,394 meters					
San Juan, Puerto Rico	1-8	12.6		0.031	8.5
18° 26′N	8-15	5.28		0.022	3.6
66° 00′W	15-22	13.3		0.032	9.0
Elev. - 10 meters	22-2/1	4.90	9.02	0.038	3.3
Miraflores, Panama Canal Zone	1-8	4.29		0.022	2.9
90° 00′N	8-15	6.57		0.038	4.4
	15-22	10.7		0.031	7.2
79° 35′W	22-2/1	10.5	7.90	0.028	7.1
Elev. - 10 meters					
Guayaquil, Ecuador[b]					
2° 10′S					
79° 52′W					
Elev. - 7 meters					
Lima, Peru	1-8	1.00		0.017	0.72
12° 06′W					
77° 01′W					
Elev. - 134 meters					
Chacaltaya, Bolivia	1-8	0.509		0.014	0.34
17° 10′S					
68° 15′W					
Elev. - 5,220 meters					
Antofagasta, Chile	1-8	0.734		0.017	0.50
23° 37′S	8-15	0.626		0.016	0.42
70° 16′W	15-22	1.16		0.071	0.78
Elev. - 519 meters	22-2/1	0.634	0.789	0.021	0.43
Santiago, Chile	1-8	0.687		0.027	0.46
33° 27′S	8-15	0.361		0.072	0.24
70° 42′W	15-22	0.525		0.021	0.36
Elev. - 520 meters	22-2/1	0.707	0.570	0.018	0.48
Puerto Montt, Chile	1-8	0.213		0.026	0.14
41° 27′S	8-15	0.279		0.042	0.19
72° 57′W	15-22	0.331	0.272	0.036	0.22
Elev. - 5 meters					
Punta Arenas, Chile	1-8	0.207		0.012	0.14
53° 08′S	8-15	0.292		0.020	0.20
70° 53′W	15-22	0.239		0.027	0.16
Elev. - 3 meters	22-2/1	0.159	0.234	0.034	0.11

[a] Scheduled to begin operation in March 1963.

[b] Data not available.

tion at a number of locations. This is presently being done only at a few research installations.

The amount of deposition collected in any given month is not large enough to allow gamma measurements, thus, these samples are analyzed radiochemically for strontium-90 and for strontium-89. These determinations will allow for some estimation of the age of the activity

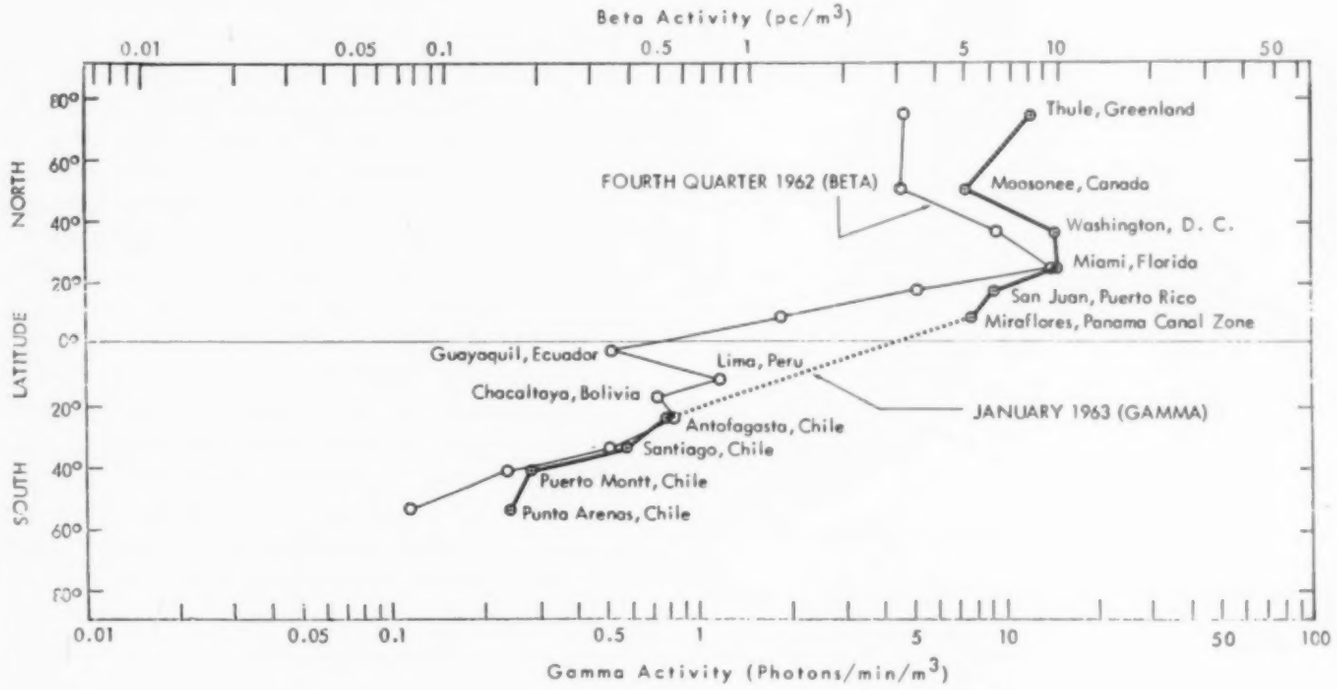

FIGURE 4.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, JANUARY 1963

and can be compared with the same determinations made on the air filters.

With this report are presented the data available for the gamma activity measurements on air filters from the 80th Meridian Network for January 1963. The data are not complete due to some mislabeling of filters and problems involved in the changeover from NRL to HASL operation of the Network.

The results are shown in table 3 including the $\gamma > 1$ Mev/total γ ratio. In addition, the estimated total beta activity has been determined for comparison with previously published data. January 1963 averages for each station have been plotted in figure 4 as a gamma activity profile. [*Editor's note: A comparison with the fourth quarter 1962 average (from NRL) has been made in figure 4 by plotting the latter against a beta activity scale, which has been shifted to account for the dpm to pc conversion and an assumed beta to photon ratio of 1.5.*]

REFERENCE

(*1*) United Nations General Assembly, Seventeenth Session: *Agenda Item 30, Report of the United Nations Scientific Committee on the Effects of Atomic Radiation—Report of the World Meteorological Organization on the Implementation of General Assembly Resolution 1629* (XVI), New York (October 8, 1962).

SECTION II.—FOOD

Radionuclides in Institutional Diet Samples
October-December 1962

Division of Radiological Health,
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is being administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selective population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) is located in a community monitored by the PHS Pasteurized Milk Network. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

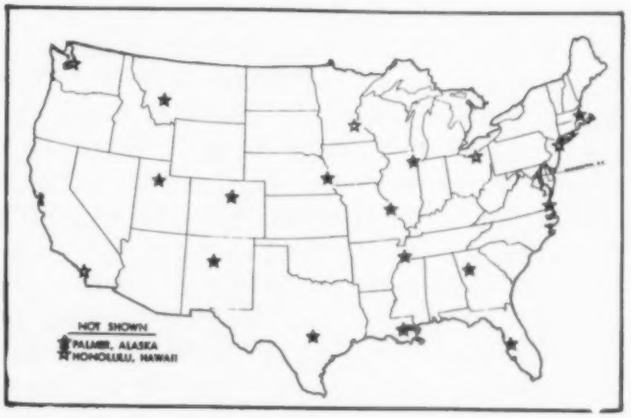

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS, DECEMBER 1962

TABLE 1.—INSTITUTIONAL DAILY DIETARY

Data	Month (1962)	Alaska, Palmer	California, Los Angeles	Colorado, Denver	Florida, Tampa	Georgia, Atlanta	Hawaii, Honolulu	Louisiana, New Orleans	Massachusetts, Boston	Minnesota, Minneapolis	Montana Helena
Age (years)		6-18	6-18	6-18	1-15	6-18	5-16	4-19	—	[a]< 1-16	4-16
Total weight (kg/day)	Oct.	2.16		2.01	1.79	1.72	1.72	2.50	1.54	1.64	2.74
	Nov.	1.64	1.19	1.88		1.82		2.49	1.52	1.50	
	Dec.	1.24	1.31	2.33	1.83	1.82	1.89	2.19	1.75	1.50	1.97
Calcium (g/day)	Oct.	1.5		1.2	1.1	0.8	0.7	1.8	0.9	0.9	1.6
	Nov.	0.9	0.9	0.6		1.0		1.6	1.1	1.1	
	Dec.	1.1	0.8	2.6	1.1	7.2	0.8	1.4	1.4	0.4	1.1
Phosphorus as phosphate (g/day)	Oct.	6.9		5.0	3.8	3.6	3.5	5.6	3.8	3.2	7.2
	Nov.	3.9	4.0	3.0		4.0		6.5	3.5	5.3	
	Dec.	3.6	3.3	16.3	4.6	4.9	3.3	6.6	4.7	3.3	4.5
Potassium (g/day)	Oct.	3.5		3.3	2.1	0.8	2.1	4.1	3.1	2.3	3.8
	Nov.	4.1	1.9	2.8		2.2		3.7	6.6	1.7	
	Dec.	1.6	1.8	6.1	3.0	2.2	2.3	3.4	3.5	1.7	3.0
Total radium (pc/day)	Oct.	1.0		3.0	< 2.0	< 2.0	11.0	4 0	< 1.0	≤ 1.0	< 1.0
	Nov.	2.0	2.0	4.0		2.4		3.8	1.0	≤ 1.0	
	Dec.	4.0	2.0	5.0	2.0	< 2.0	5.0	< 3.0	< 1.0	≤ 1.0	3.0
Strontium-89 (pc/day)	Oct.	100		200	< 10	< 10	15	≤ 20	35	85	50
	Nov	30	10	5		30		≤ 15	25	130	
	Dec.	25	10	40	20	160	25	45	20	10	15
Strontium-90 (pc/day)	Oct.	37		20	14	18	6	43	14	20	21
	Nov.	21	10	13		12		31	14	3	
	Dec.	21	3	57	12	17	12	28	16	9	16
Cesium-137 (pc/day)	Oct.	110		100	70	< 10	25	100	100	65	80
	Nov.	70	5	85		35		75	180	60	
	Dec.	20	20	235	120	55	65	110	205	55	80
Barium-140 (pc/day)	Oct.	≤ 10		≤ 10	< 20	≤ 20	< 10	≤ 30	10	≤ 10	< 10
	Nov.	≤ 10	≤ 10	≤ 10		≤ 20		≤ 30	< 10	≤ 10	
	Dec.	< 10	< 10	< 10	< 20	< 20	< 10	< 30	60	< 10	< 10
Iodine-131 (pc/day)	Oct.	< 10		≤ 10	< 20	50	50	< 30	20	≤ 10	< 10
	Nov.	390	≤ 10	≤ 10		≤ 20		30	< 10	≤ 10	
	Dec.	< 10	< 10	70	< 20	< 20	< 10	70	45	< 10	< 10

[a] Food samples not collected for children too young for solid diet.

Sampling Procedure

In general, the sampling procedure is the same in each case. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After compositing the total sample, it is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three containers: One containing solid food minus seeds, pits, rinds, shells and bones that would not ordinarily be eaten; one containing dairy products such as milk, cottage cheese, and ice cream; and one containing soft drinks, coffee and tea. A record of the contents of each meal and the approximate weight of each item is made by the institution's dietician and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Procedures

Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique. Because calcium and phosphorus compounds may have an effect on the uptake of important boneseeking radionuclides such as strontium-89 and strontium-90 (*2*), they are included in the analytical program.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium-89 and strontium-90 with subsequent counting, and (3) total radium analysis. In the absence of

INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

Data	Month (1962)	Nebraska, Omaha	New Mexico, Albuquerque	Ohio, Cleveland	Tennessee, Memphis	Texas, Austin	Utah, Salt Lake City	Virginia, Norfolk	Washington, Seattle	Monthly minimum average	Monthly maximum average
Age (years)		6-8	5-14	6-15	8-18	6-18	12-18	10-18	6-16	—	—
Total weight (kg/day)	Oct.	1.65	1.77	1.80	1.39	2.57	1.33	1.17	2.27	1.87	1.87
	Nov.	1.63	1.72	1.73	1.17	3.35	1.59	1.17	2.83	1.82	1.82
	Dec.	1.05	1.62	1.77	1.06	2.29	1.35	1.34	2.61	1.62	1.62
Calcium (g/day)	Oct.	1.3	1.2	1.5	1.1	1.2	1.0	0.6	3.2	1.3	1.3
	Nov.	0.8	1.1	1.5	0.9	1.8	1.4	0.6	2.0	1.2	1.2
	Dec.	0.8	1.4	1.3	0.7	1.1	1.0	0.7	2.1	1.2	1.2
Phosphorus as phosphate (g/day)	Oct.	4.8	3.9	4.8	3.4	5.3	3.8	2.5	5.7	4.5	4.5
	Nov.	5.6	4.9	4.0	3.0	7.7	3.6	2.7	7.7	4.7	4.7
	Dec.	5.6	8.3	4.8	2.9	5.2	3.1	3.3	5.9	4.2	5.2
Potassium (g/day)	Oct.	2.8	3.2	7.5	2.4	3.2	2.1	1.5	1.4	2.9	2.9
	Nov.	2.0	2.4	6.0	2.0	4.9	2.5	1.7	4.8	3.3	3.3
	Dec.	2.0	3.1	3.2	1.7	3.4	2.2	2.0	3.7	2.8	2.8
Total radium (pc/day)	Oct.	< 1.0	2.0	3.0	1.4	2.9	< 1.0	< 2.0	4.0	1.8	2.5
	Nov.	2.0	2.0	2.0	1.3	≤ 4.0	6.0	1.5	< 1.0	2.0	2.4
	Dec.	2.0	2.0	2.0	< 2.0	< 2.0	3.0	< 2.0	8.0	2.1	2.8
Strontium-89 (pc/day)	Nov.	65	35	< 5	< 10	< 15	35	< 10	115	43	48
	Oct.	25	25	15	25	60	50	40	115	39	40
	Dec.	25	40	40	25	35	35	45	145	42	42
Strontium-90 (pc/day)	Oct.	19	11	2	19	15	8	15	17	18	18
	Nov.	9	8	12	10	16	13	9	64	16	16
	Dec.	9	8	5	11	16	9	16	44	17	17
Cesium-137 (pc/day)	Oct.	40	25	100	15	50	65	40	90	63	64
	Nov.	35	< 10	80	25	135	85	35	110	72	73
	Dec.	35	40	140	25	90	75	45	155	90	90
Barium-140 (pc/day)	Oct.	< 10	≤ 10	< 10	≤ 20	≤ 30	≤ 10	≤ 20	≤ 10	< 1	15
	Nov.	10	< 10	10	≤ 20	≤ 40	≤ 10	≤ 20	≤ 10	1	15
	Dec.	10	110	30	< 20	< 30	< 10	< 20	< 10	12	24
Iodine-131 (pc/day)	Oct.	≤ 10	320	< 10	< 20	< 30	≤ 10	10	≤ 10	26	37
	Nov.	≤ 10	< 10	20	20	70	≤ 10	≤ 20	≤ 10	35	43
	Dec.	< 10	160	70	30	70	< 10	< 20	< 10	29	36

interferences other than naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan on a per-kilogram basis are: I-131, 10 pc/kg; Cs-137, 5 pc/kg; and Ba-140, 10 pc/kg. Approximate minimum detectable concentrations for Sr-89, Sr-90, and total radium are: 5, 1, and 1 pc/kg, respectively.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After transfer to planchets and drying, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from October 1962 through December 1962 for the 18 institutions from which samples were received. The reported iodine-131 values are based on the iodine-131 content of the sample at the end of the sample collection period. Therefore, the true iodine-131 intakes may be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less than" values are considered to be zero.

Strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 averages of the daily intakes at the institutions, as well as announced atmospheric nuclear detonations for 1961 and 1962, are shown in figure 2.

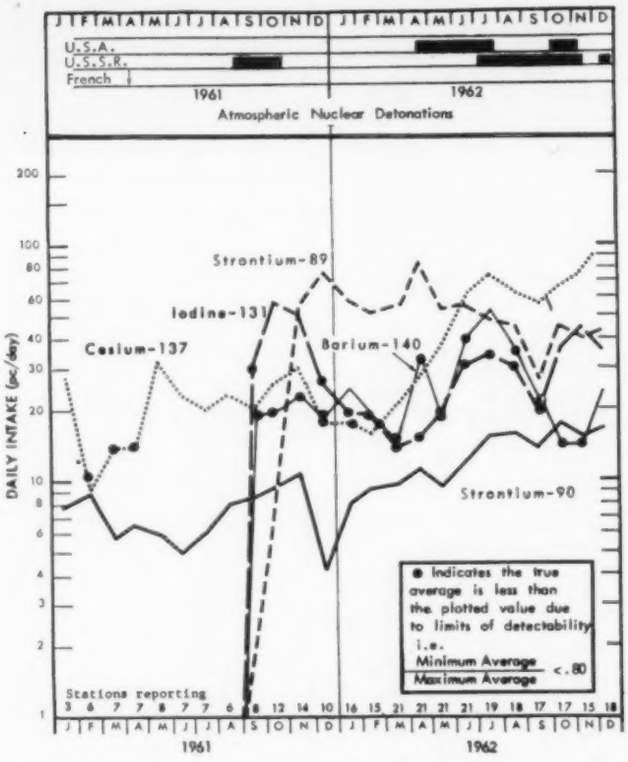

FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

For rapid comprehension, the data are presented graphically in figures 3-10 as station distributions versus daily intake. These are not graphs of continuous functions as might be inferred from their appearance. For example, in figure 3 total dietary intake of food is divided into six ranges (< 1.00, 1.00-1.49, 1.50-1.99, 2.00-2.49, 2.50-2.99 and 3.00-3.50 kg/day), and the number of institutions in each range is noted and plotted as a bar graph. The maximum of each bar is connected by a smooth curve. This type of construction is used for each month for each item represented.

The number of stations used in constructing these graphs was 17, 15, and 18 for the months of October, November and December 1962, respectively. It is, of course, acknowledged that a variation of two institutions may not be significant in considering trends in the data.

Discussion of Data

During the 3-month period reported, the dietary intake of strontium-90 ranged between 2 and 64 pc/day, with 38 of 50 institution-months * being in the lowest Federal Radiation Council (FRC) Range of Transient Rates of intake. The lowest Range established by the FRC is 0 to 20 pc/day for strontium-90 (*3,4*)

The strontium-89 distribution (figure 8) shows that the majority of institutions reported values below 40 pc/day. The lowest FRC Range for strontium-89 is 0 to 200 pc/day (*3*).

The dietary intake of total radium ranged between < 1.0 and 12.0 pc/day with 96 percent of the institution-months being 6.0 pc/day or less. Assuming the radium-226 component to be one-third of the total radium activity (*3*), the intake of radium-226 via the diet probably approaches the top of FRC Range I (0 to 2 pc/day for radium-226) at a few institutions.

Following the resumption of nuclear weapons testing in the atmosphere in 1961, iodine-131 dietary intake increased from nondetectable levels to an institutional high of 390 pc/day. This value occurred during October-December 1962, but only three institution-months were greater than 100 pc/day. FRC Range II for iodine-131 is 10-100 pc/day (*3*).

The cesium-137 dietary intake has ranged from < 5 to 235 pc/day during the period reported. The distribution of institutions (figure 10) is relatively flat from 0 to 120 pc/day. All institutions showed an increase in the cesium-137 intake during this quarter. This can be seen in the average of institutions graph, figure 2.

The distributions of total weight intake of food for this quarter (figure 3) are similar to those for the previous period. The total weight of food consumed ranged between 1.06 and 3.35 kg/day, with most institutions reporting between 1 and 2 kg/day.

The calcium intake average of institutions (table 1) has normally ranged between 1.0 and 1.3 g/day while the calcium distribution (figure 4) usually has a well-defined peak. This quarter's results for calcium follow this same pattern.

* An institution-month is one datum value per institution per month. (e g., 20 institutions reporting one value per month for 3 months is 60 institution-months).

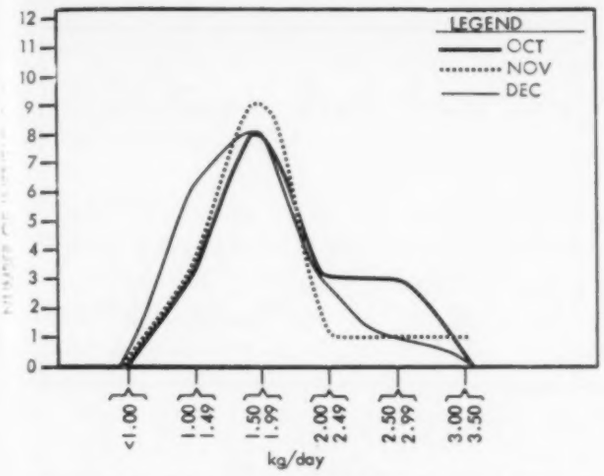

FIGURE 3.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS TOTAL DAILY DIETARY INTAKE ON A WEIGHT BASIS

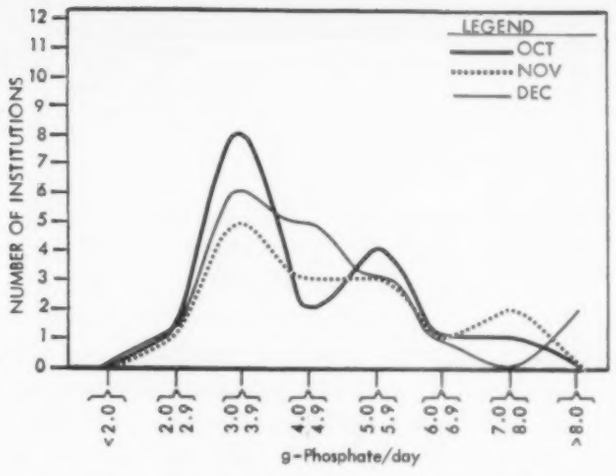

FIGURE 6.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY PHOSPHATE INTAKE

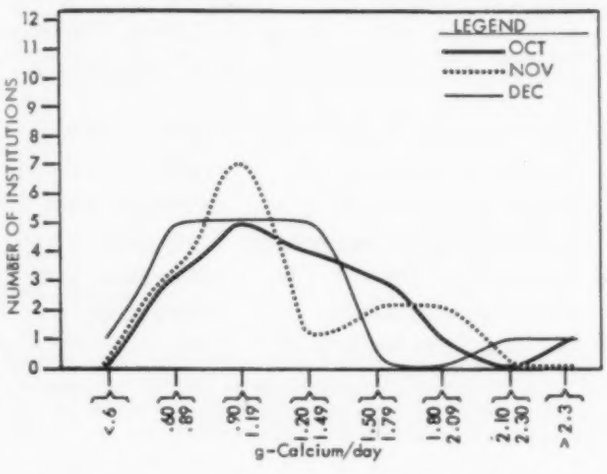

FIGURE 4.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CALCIUM INTAKE

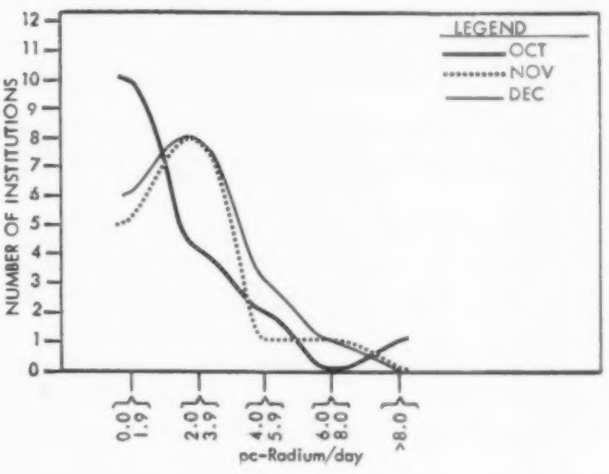

FIGURE 7.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY TOTAL RADIUM INTAKE

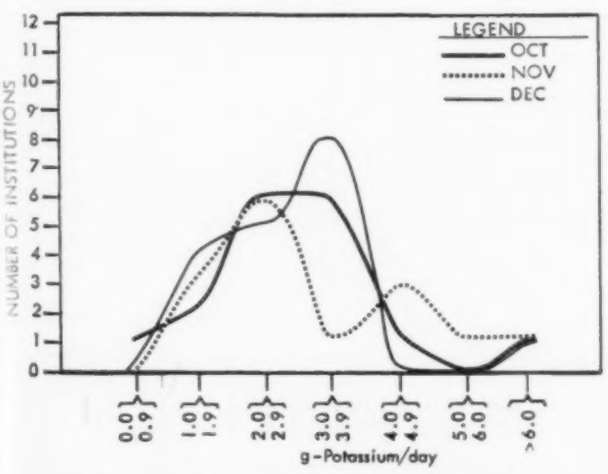

FIGURE 5 -- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY POTASSIUM INTAKE

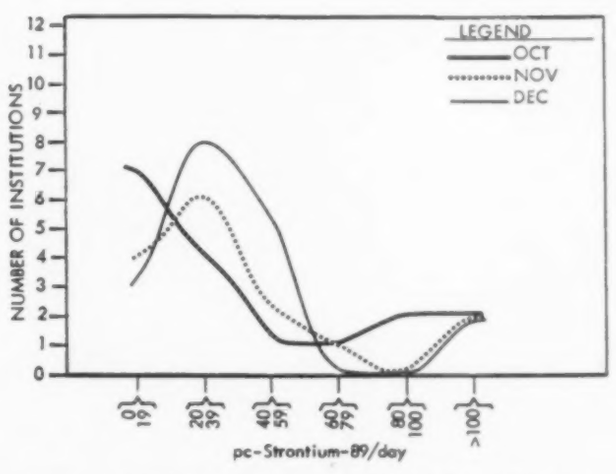

FIGURE 8-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-89 INTAKE

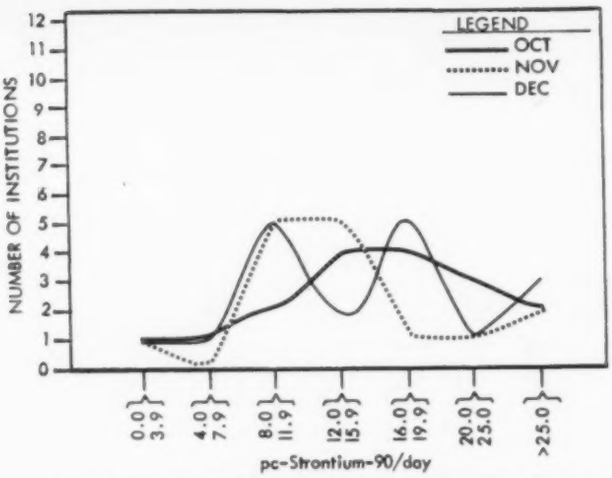

FIGURE 9.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY STRONTIUM-90 INTAKE

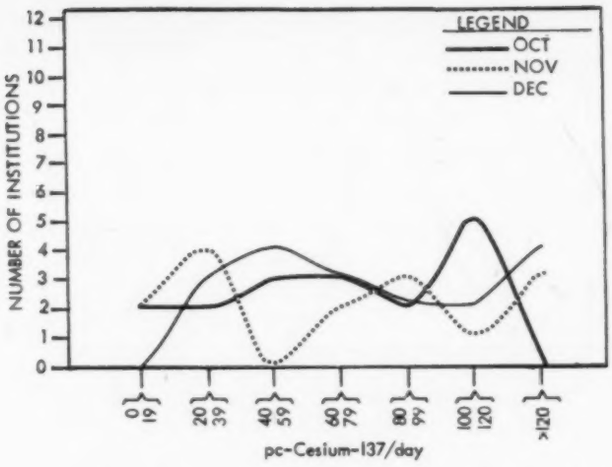

FIGURE 10.-- DISTRIBUTIONS OF INSTITUTIONS VERSUS DAILY CESIUM-137 INTAKE

REFERENCES

(1) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52:* 1391-400 (September 1962).

(2) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology 1*:369-96 (1961).

(3) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (September 1961), price 20 cents.

(4) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3:* 159-65 (May 1962).

Previous coverage in *Radiological Health Data:*

Period	*Issue*
January-August 1961	*February 1962*
January 1961-February 1962	*July 1962*
March-June 1962	*December 1962*
July-September 1962	*April 1963*

Selected Results From Total Diet Studies *

May 1961-June 1962

Since November 1959, the Consumers' Union (CU) has engaged in studies of the radionuclide content of samples of teen-agers' total diet collected at various periods of the year from groups of selected U. C. cities (*1-5*). It is believed that the selection of the teen-ager group for study will produce estimates of dietary radionuclide intake which are not likely to be exceeded by the general population. A basis for this is found in the National Research Council's recommended dietary allowances (*6*), which establish the relatively high nutritional needs of teen-agers as compared with other age groups.

Originally, diet samples from 25 U. S. cities were analyzed; as of the January 1962 sampling, the number of cities included was increased to 30. Of the original group of 25 cities sampled in November 1959, 5 cities have been included in all succeeding samplings, and dating from the May 1961 sampling, 10 cities have been consistently sampled among the 30 selected cities (figure 1). Beginning with the January 1962 sampling, two groups of 10 cities each have been included on an alternating basis with the basic group of 10 cities. Thus, each sampling from January 1962 through June 1962 includes 20 cities. This report presents CU teen-age diet data for the period from May 1961 through June 1962. Consumers' Union infant diet data from selected cities for the period June 1961 through June 1962 are also presented.

Sampling Procedures

Each diet sample from a city consisted of the total diet (food, milk, and drinking water) of teen-agers for a full week (21 meals plus snacks). To help assure that the various diet samples, though consisting of the same kinds of foods, would be as representative of the diet in the region in which a selected city was situated, home economists in universities were asked to prepare (on the basis of local surveys) diets as nearly identical as possible in composi-

* Based on data from studies performed by Mr. Irving Michelson, Director of Public Service Projects, Consumers' Union, in fulfillment of Public Health Service contracts SAph 76694 and PH 86-62-82. Analyses were done by Isotopes, Inc., Westwood, New Jersey.

FIGURE 1.—CONSUMERS' UNION DIET SAMPLING LOCATIONS, MAY 1961-JUNE 1962

TABLE 1.—TEEN-AGER AVERAGE DAILY DIETARY I

Sampling location		Weight (kg/day)					Calcium (g/day)				
		May 1961	January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	J
Ark:	Little Rock		2.61		3.09			0.84		0.68	
Calif:	Los Angeles [a]	3.03	4.37	3.33	3.26	3.76	1.33	1.75	1.66	1.43	
	San Francisco		3.64		4.06			2.29		1.18	
Colo:	Denver [a]	2.97	3.34	3.37	3.39	3.10	1.69	1.77	1.89	2.00	
D. C:	Washington		3.34		3.27			1.77		1.60	
Fla:	Miami			3.94		3.20			2.21		
Ga:	Atlanta		3.48		3.47			1.91		1.94	
Ill:	Chicago [a]	3.68	3.74	4.00	3.87	4.11	1.69	2.02	2.24	2.21	
Ky:	Louisville			3.87		2.34			2.28		
Kans:	Wichita			3.51		3.38			2.18		
La:	New Orleans [a]	2.54	3.57	3.53	3.64	3.73	0.76	2.14	2.22	1.93	
Maine	Portland			3.56		3.86			1.57		
Mass:	Boston [a]	4.59	5.84	4.00	5.39	5.41	2.20	2.16	2.20	2.80	
Mich:	Detroit		3.50	3.34	3.21	3.91		1.96		1.73	
Minn:	Duluth								1.64		
Nev:	Las Vegas			3.96		3.50			2.14		
N. Dak:	Bismarck		3.96		3.91			2.10		1.84	
N. Y:	Buffalo		3.14		3.97			1.63		2.14	
	New York [a]	3.39	3.40	3.77	3.56	3.58	1.73	1.63	2.00	2.06	
Ohio	Cincinnati			3.54		3.36			1.84		
Ore:	Portland		3.44		4.06			1.65		1.91	
Pa:	Philadelphia			4.17		4.44			2.34		
S. Dak:	Sioux Falls [a]	3.48	3.21	3.29	3.51	3.61	1.78	2.18	2.01	2.14	
Tenn:	Knoxville [a]	3.51	3.88	3.40	3.33	3.56	1.58	2.52	2.11	2.33	
Tex:	Austin			3.70		3.83			1.89		
	El Paso [a]	3.49	3.51	3.54	3.51	3.18	1.68	2.55	2.27	2.18	
Utah	Salt Lake City		2.66		2.19			1.46		1.07	
Wash:	Seattle			4.24		4.31			2.29		
	Spokane [a]	3.44	3.58	3.51	3.61	3.04	1.89	2.54	2.25	2.24	
Wis:	Madison		3.77		3.57			2.07		2.14	
Average (arithmetic)		3.41	3.60	3.68	3.59	3.66	1.63	1.95	2.06	1.88	
10-city average [a]		3.41	3.84	3.57	3.72	3.71	1.63	2.13	2.09	2.13	

[a] These cities were used in constructing figure 2 (a-c), since complete data for these cities are available.
[b] Strontium-89 not detectable in May 1961.

tion and weight to the average local diet of male teen-agers with healthy appetities. The home economist purchased in local markets fresh produce when available, and when necessary chose frozen and canned items as substitutes. A variety of brands of each item was also brought.

Typical items in the menus were hot and cold cereal, eggs, bread, milk and other dairy products, spaghetti, beef, lamb, pork, chicken, fish, salads, vegetables, soups, fruits, fruit juices, and drinking water. Also included were snacks containing soft drinks, candy, cookies, sandwiches, cake, and ice cream. Meals were prepared, including cooking and seasoning, as they would be for actual consumption. Inedible parts, such as bones, excess fats, skins, shells, pits, and cores were discarded. After preparation, the samples were shipped to the CU contract laboratory for analysis. Selected samples were sent to Public Health Service (PHS) laboratories for cross-checking.

In addition to these analyses, for the 10 cities which were consistently sampled, separate milk samples which were representative of the milk in the total diet samples were analyzed to determine the contribution of this item to the total dietary intake.

Analytical Program and Methods

The 1961 program included analyses of each sample for cerium-144, cesium-137, zinc-65, radium-226, potassium-40, strontium-90, and stable calcium. The 1962 program, which was conducted following the resumption of weapons testing, was designed to obtain data on concentrations of strontium-89, strontium-90, cesium-137 and stable calcium. The milk samples from ten cities were also analyzed for iodine-131. Both programs provided for the preparation of split samples as a check on the analytical procedures.

The calcium analysis has been derived from a procedure described by Yalman and Boulgerman (7). Strontium-90 was determined by beta counting its daughter yttrium-90 which had been chemically separated from the sample

RAGE BASED ON SEVEN DAYS) MAY 1961 - JUNE 1962

Strontium-89 (pc/day)				Strontium-90 (pc/day)					Cesium-137 (pc/day)				
January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	June 1962	May 1961	January 1962	March 1962	May 1962	June 1962
26		70			8.6		16.4			29		68	
8	121	17	15	5.7	14.4	12.0	4.6	6.0	16	52	47	23	34
41		54			6.9		11.8			29		53	
30	31	35	42	8.4	11.4	9.4	15.9	18.9	22	27	40	51	81
42		95			14.4		16.0			27		49	
	95		22			12.6		10.9			126		102
96		141			26.4		33.0			38		142	
40	[c] 4	6	112	9.6	12.3	16.8	12.4	21.4	45	37	60	46	127
	23		30			19.0		16.6			39		44
	[c] 7		148			16.1		29.4			25		112
493	537	305	234	8.5	35.3	51.5	48.8	72.4	40	107	159	158	325
	[c] 4		65			18.9		34.4			61		154
12	8	5	67	20.7	30.4	32.4	30.7	45.4	77	[d] —	40	75	179
11		124			11.9		12.5			21		45	
	23		177			11.7		46.9			53		285
	42		32			7.5		9.8			44		32
[c] 5		19			12.3		18.0			36		51	
6		4			13.5		22.6			31		48	
29	[c] 4	6	122	12.2	12.6	18.1	24.2	30.4	28	51	57	68	132
	37		128			13.1		24.9			46		144
21		123			11.4		32.5			34		252	
	32		56			17.1		43.5			88		160
25	25	33	212	10.2	10.6	11.8	14.4	36.5	26	32	43	77	141
59	168	206	136	16.4	21.0	26.2	46.0	35.6	41	39	68	143	167
	61		[c] <15			14.8		39.8			52		123
43	54	36	22	6.3	10.9	16.3	8.1	15.6	30	21	28	25	38
15		16			6.9		6.4			21		26	
	29		125			14.4		40.5			59		228
[c] 4	15	43	51	12.6	16.8	12.3	20.9	21.6	47	43	49	40	100
25		36			11.3		13.6			38		64	
51.5	66.0	68.7	90.6	11.1	15.0	17.5	20.1	30.0	37.2	37.5	59.2	75.0	131.9
74.3	96.6	69.2	101.3	11.1	17.6	20.7	22.6	30.4	37.2	45.4	59.1	70.1	132.4

[c] Less-than values were used as the whole number in computing the strontium-89 average.
[d] Unusually high values obtained, not verified by correlation samples.

Strontium-89 was differentially estimated by beta counting the total radio-strontium in the sample. Cesium-137 determinations were made by beta counting after chemical separation.

Sampling Results

Table 1 presents strontium-89, strontium-90, and cesium-137, plus total weight consumed and stable calcium results. The total weight of food consumed ranged between 2.19 and 5.84 kilograms/day, with most intakes falling between 3 and 4 kilograms/day. The daily calcium intake ranged between 0.68 and 2.80 grams/day, with about 80 percent of the intakes falling between 1.5 and 2.5 grams/day.

Strontium-89 intake averages for the selected 10 cities are plotted in figure 2a. The average increased by about 33 percent between January 1962 and June 1962. It can be observed in table 1 that New Orleans consistently reported higher levels than the other cities. The maximum value reported for New Orleans was 537 pc/day in March 1962.

The strontium-90 intake values observed during the study ranged between 4.6 and 72.4 pc/day. The average of the 10 selected cities increased from 11.1 pc/day in May 1961 to 30.4 pc/day in June 1962 (figure 2b). Highest levels were noted in New Orleans, and lowest levels were observed in Los Angeles and El Paso. The highest value, 72.4 pc/day, occurred in June 1962.

The 10-city average for cesium-137 increased gradually from May 1961 to May 1962 and turned sharply upward in June 1962 (figure 2c). A high value of 325 pc/day was observed in New Orleans in June 1962.

Table 2 presents data on additional radionuclide values obtained for the basic group of 10 cities during the May 1961 sampling. Among these radionuclides, potassium-40 and radium-226 occur naturally in the diet, and cerium-144 is a fission product. The highest intake of stable potassium, as well as the highest value for potassium-40, was noted at Boston. The highest cerium-144 intake, 3.0 pc/day, occurred at New Orleans. The peak intake of

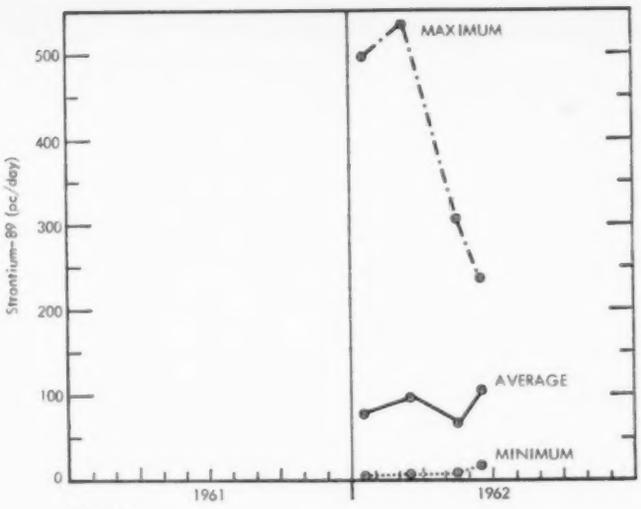

Figure 2a

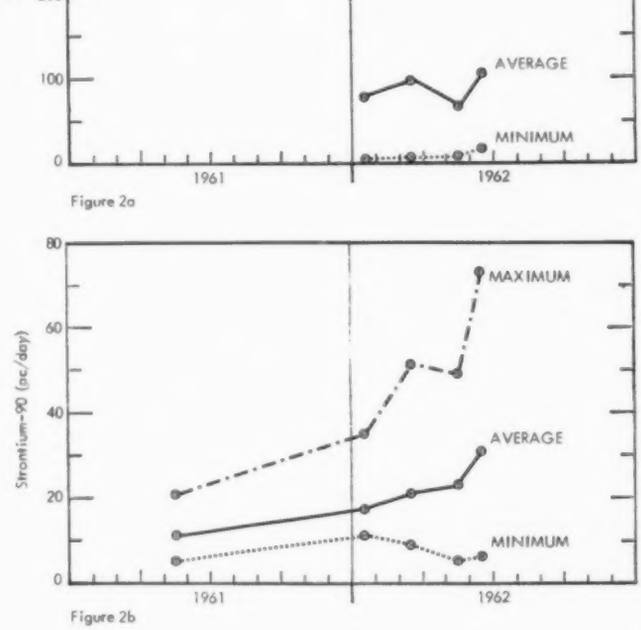

Figure 2b

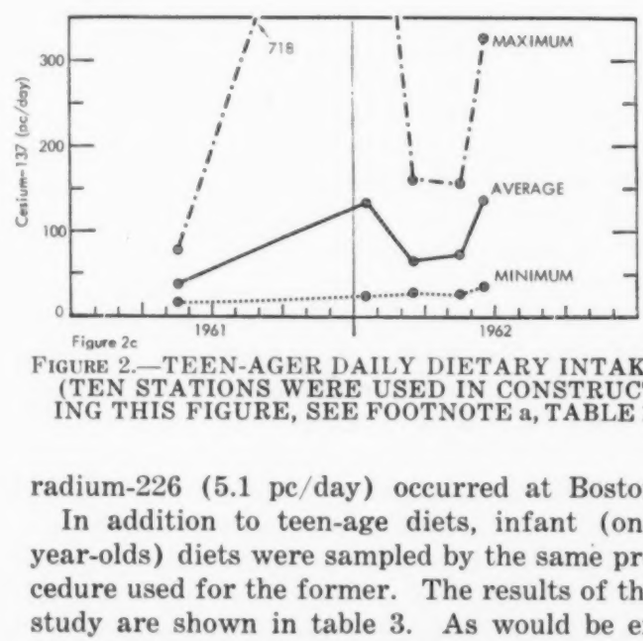

Figure 2c

FIGURE 2.—TEEN-AGER DAILY DIETARY INTAKE (TEN STATIONS WERE USED IN CONSTRUCTING THIS FIGURE, SEE FOOTNOTE a, TABLE 1)

radium-226 (5.1 pc/day) occurred at Boston.

In addition to teen-age diets, infant (one-year-olds) diets were sampled by the same procedure used for the former. The results of this study are shown in table 3. As would be expected, the weights of food consumed were considerably less, ranging between 1.14 and 2.33 kilograms/day. Correspondingly, the calcium intake ranged between 0.8 and 1.77 grams/day. Although only limited comparisons between the

TABLE 2.—TEEN-AGER DIETARY DAILY INTAKE, MAY 1961

Sampling location		Potassium (g/day)	Potassium ^{40} (pc/day)	Cerium ^{144} (pc/day)	Radium ^{226} (pc/day)
Calif:	Los Angeles	3.6	3,100	1.5	1.5
Colo:	Denver	4.8	4,000	1.2	2.1
Ill:	Chicago	6.2	5,300	1.8	3.3
La:	New Orleans	3.5	2,900	3.0	2.0
Mass:	Boston	7.1	6,100	2.8	5.1
N.Y:	New York	3.6	3,100	2.0	2.4
S. Dak:	Sioux Falls	5.4	4,600	1.4	1.8
Tenn:	Knoxville	5.5	4,700	1.8	1.8
Tex:	El Paso	4.9	4,200	2.4	1.8
Wash:	Spokane	4.2	3,600	1.7	1.7
Average		4.9	4,160	2.0	2.4

TABLE 3.—INFANT AVERAGE DAILY DIETARY INTAKE (AVERAGE BASED ON SEVEN DAYS) JUNE 1961-JUNE 1962

Sampling location and date		Weight (kg/day)	Calcium (g/day)	Strontium-89 (pc/day)	Strontium-90 (pc/day)	Cesium ^{13} (pc/day)
June 1961						
Calif:	Los Angeles	1.57	0.97		1.6	8
Colo:	Denver	2.17	0.85		4.8	16
Ill:	Chicago	2.30	1.24		6.4	25
La:	New Orleans	1.74	1.34		20.1	33
Mass:	Boston	1.59	1.30		11.8	39
N.Y:	New York	1.67	1.77		9.5	44
S. Dak:	Sioux Falls	2.21	1.37		7.9	26
Tenn:	Knoxville	1.29	0.84		6.2	23
Tex:	El Paso	2.10	1.03		2.7	16
Wash:	Spokane	1.33	1.10		6.1	28
Averages		1.80	1.18		7.7	25.8
January 1962						
Calif:	Los Angeles	2.01	1.45	25	4.0	32
D.C:	Washington	1.64	1.00	17	6.1	13
Ill:	Chicago	1.63	1.01	7	5.4	21
Mich:	Detroit	1.26	0.93	5	2.3	15
Averages		1.63	1.10	13.5	4.5	20.2
March 1962						
Colo:	Denver	1.60	0.86[a]	< 2	5.6	18
N.Y:	New York	1.53	1.12	< 2	8.3	14
Ohio:	Cincinnati	1.14	0.80	92	4.6	16
Pa:	Philadelphia	1.56	1.39	3	8.0	19
Averages		1.46	1.04	24.8	6.6	16.8
May 1962						
Calif:	San Francisco	1.59	1.08	38	8.1	33
Ga:	Atlanta	1.33	1.09	90	21.9	89
Mass:	Boston	2.33	1.40	< 2	11.2	23
Texas:	El Paso	1.87	1.42	15	3.6	13
Averages		1.78	1.25	36.2	11.2	39.5
June 1962						
Kans:	Wichita	2.26	1.33	86	15.8	72
Nev:	Las Vegas	1.78	0.85	12	4.1	25
S. Dak:	Sioux Falls	1.71	0.96	106	22.6	74
Wash:	Spokane	1.70	1.63	137	25.5	124
Averages		1.86	1.19	85.2	17.0	73.8

[a] The less-than values were used as the whole number in computing the strontium-90 averages.

averages of groups of different cities (shown in table 3) may be made, it may be observed that the average strontium-89, strontium-90, and cesium-137 intakes increased from March 1962 to June 1962.

In order to compare the calcium intake from milk with the calcium intake from the total diet of teen-agers, table 4 displays the ratio of the intake of calcium from milk to that

from the diet. These ratios were calculated by dividing the daily calcium intake from milk by the daily calcium intake from the total diet. Table 5, derived in a similar fashion, shows the ratio of the intake of strontium-90 from milk to that from the total diet. Total diet samples, including milk, were analyzed. Milk samples were also analyzed. The ratio of the total diet values to milk values may therefore be greater than unity because of analytical errors. The average ratio of intake of calcium from milk to that from the total diet increased significantly in June 1962, when the average levels of strontium-90 were highest. Notably low values for strontium-90 in milk, as compared with those in the diet, were reported for Los Angeles.

For convenience, table 6 is arranged to show the relative contribution of milk to the total dietary intake using the results from the 10 cities in tables 4 and 5. The distribution of the ratios of calcium in milk to the ratios of calcium in the total diet have a sharply defined range. Twenty-four of 40 observations indicate that the calcium milk/diet ratio is between 0.60 and 0.69. The strontium-90 milk/diet ratios have a flatter distribution. However, 28 of 40 observations lie between 0.30 and 0.79.

TABLE 4.—RATIOS OF CALCIUM INTAKE FROM MILK RELATIVE TO CALCIUM INTAKE FROM THE TOTAL DIET, JANUARY-JUNE 1962

Sampling location		January	March	May	June
Calif:	Los Angeles	0.36	0.46	0.64	0.60
Colo:	Denver	0.73	0.57	0.53	0.64
Ill:	Chicago	0.64	0.60	0.61	0.62
La:	New Orleans	0.67	0.62	0.73	0.67
Mass:	Boston	0.60	0.64	0.50	0.49
N.Y:	New York	0.71	0.70	0.70	0.63
S. Dak:	Sioux Falls	0.63	0.50	0.64	0.65
Tenn:	Knoxville	0.55	0.69	0.58	0.65
Tex:	El Paso	0.60	0.61	0.60	0.68
Wash:	Spokane	0.56	0.63	0.62	0.90
Averages		0.61	0.60	0.62	0.65

TABLE 5.—RATIOS OF STRONTIUM-90 INTAKE FROM MILK RELATIVE TO STRONTIUM-90 INTAKE FROM THE TOTAL DIET, JANUARY-JUNE 1962

Sampling locations	January	March	May	June
Boston	0.35	0.30	0.30	0.39
Chicago	0.49	0.28	0.41	0.79
Denver	0.41	0.47	0.52	0.42
El Paso	0.43	0.34	0.27	0.24
Knoxville	0.45	0.66	0.57	0.87
Los Angeles	0.07	0.16	0.26	0.22
New Orleans	0.76	0.66	0.79	0.70
New York	0.55	0.43	0.36	0.80
Sioux Falls	0.62	0.36	0.59	0.93
Spokane	0.46	[a] 1.00	0.65	[a] 1.05
Averages	0.46	0.47	0.47	0.64

[a] Because of analytical error at low levels, values larger than 1 are possible.

TABLE 6.—COMPARISON OF STRONTIUM-90 IN MILK TO THAT IN THE TOTAL DIET AND COMPARISON OF CALCIUM IN MILK TO THAT IN THE TOTAL DIET[a]

Ratio range: milk/total diet	Strontium-90	Calcium
0.00-0.09	1	0
0.10-0.19	1	0
0.20-0.29	5	0
0.30-0.39	7	1
0.40-0.49	9	2
0.50-0.59	4	7
0.60-0.69	4	24
0.70-0.79	4	5
0.80-0.89	2	0
0.90-1.00	3	1

[a] Values are the number of observations in each milk to total diet ratio range.

Analysis and Discussion

The inclusion of dietary radionuclide intake data for May 1961 permits a limited evaluation of the effects of the resumption of nuclear testing in September 1961. For example, no strontium-89 was evident in the May 1961 sampling but it was clearly apparent in the January 1962 sampling, and rose in June 1962 to the highest 10-city average. The maximum reported intake value of 537 pc/day for strontium-89 in New Orleans in March 1962 is about one-fourth of the top of FRC Range II—200 pc/day.

Again, in the case of strontium-90, New Orleans was observed to have the highest of the 10-city average levels. The maximum observed intake value of 72.4 pc/day is about one-third of the top of FRC Range II—200 pc/day.

Of lesser magnitude, compared to existing standards, is the dietary intake of cesium-137. For analysis, it may be assumed that the maximum permissible concentration (MPC) of cesium-137 for the general population is 0.01 times the occupational MPC set by the International Committee on Radiation Protection, and that the occupational MPC for cesium-137 in water for continuous exposure is 200 pc/cc (*9*). Additionally, it may be assumed that man consumes 2.2 liters of water a day. Hence, the maximum permissible daily intake of cesium-137 is estimated to be about 4,400 pc/day. This is considerably in excess of the highest observed intake for cesium-37 of 325 pc/day.

The maximum observed dietary intake aver-

age value for radium-226 of 5.1 pc/day in May 1962 is about one-fourth of the top of FRC Range II for this naturally occurring radionuclide.

Another naturally occurring isotope that exposes the body to radiation is potassium-40. This isotope delivers a dose-rate to gonadal tissue of about 17 and 2 mrem per year from beta- and gamma-radiation, respectively. This may be compared to the guidance value the FRC has established—500 mrem/year for the exposure of individuals in the population to all sources of radiation.

Table 6 shows the relationship of strontium-90 in milk to strontium-90 in the total diet. The widespread distribution of strontium-90 in milk as compared to strontium-90 in diet gives some indication that only a relative idea of the strontium-90 intake from the diet can be obtained from observing the strontium-90 intake from milk.

The relationships of the calcium in milk and calcium in diet distributions shown in Table 6 are of interest. The well-defined distribution of calcium in milk as compared to calcium in diet gives some indication that only a relative idea of the strontium intake from the diet can be obtained from observing the strontium intake from milk.

Summary

Strontium-89 was not detectable in the May 1961 teen-age diet sampling, but levels between 51.5 and 90.6 were found in the first half of 1962. Similar trends were noted for strontium-90 and cesium-137, with the greatest increases observed in June 1962.

The infant diet sampling showed increases in strontium-89, strontium-90, and cesium-137 similar to those in the teen-age diet for the same sampling period.

The daily intake values observed for strontinum-89, strontium-90, and radium-226 intakes fall in FRC Range II.

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Correction for June 1963 issue:

Radiological Health Data regrets the error appearing in table 1 on page 286 of the June issue. The date shown in the second title box should be May 1962 instead of May 1963.

SECTION III.—MILK

Milk Surveillance

Milk is the single food item often used as an indicator of the population's intake of radionuclides from the environment, although it is only one of the many sources of dietary intake of radionuclides. A number of factors account for its use as an indicator food. For example, milk is consumed by a large proportion of the U. S. population. It is produced on a regular basis throughout the country, and it is more easily sampled and analyzed than most other foods. Further, when properly composited from individual milk processing plants, milk samples are representative of the milk consumed in a marketing area.

PASTEURIZED MILK NETWORK
March 1963

Division of Radiological Health and
Division of Environmental Engineering and Food Protection,
Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a 12-station raw milk monitoring network, which was established by the Service in 1957. One of the primary objectives of this early network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a 46-station pasteurized milk sampling program in July 1960. The 46 stations were selected to provide general nationwide coverage of milk production and consumption areas.

As further needs developed, more milk sampling points were added, through July 1962, when the total number of stations reached was 62. Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. After collection, the composites are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, and Northeastern Radiological Health Laboratories for analyses. Approximately 3-6 days after sample collection, any results from gamma analyses of iodine-131 which indicate concentrations of this radionuclide greater than 100 pc/liter are made available to State public health officials and the Federal Radiation Council for possible public health action. Complete analytical results are available six to seven weeks after sample collection and publication in *Radiological Health Data* follows 3 to 4 months after sample collection because of the time required for shipment, processing, analysis of radiostrontium, data compilation and publication procedures.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in

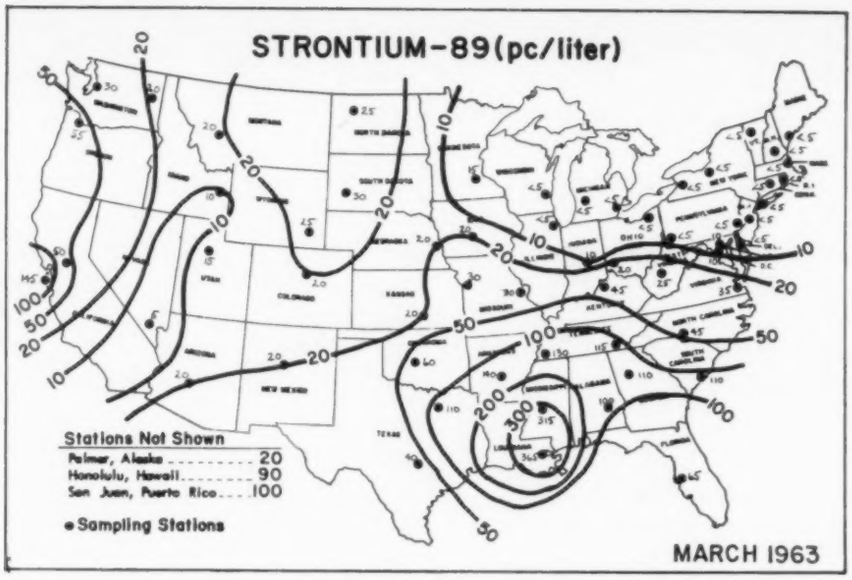

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

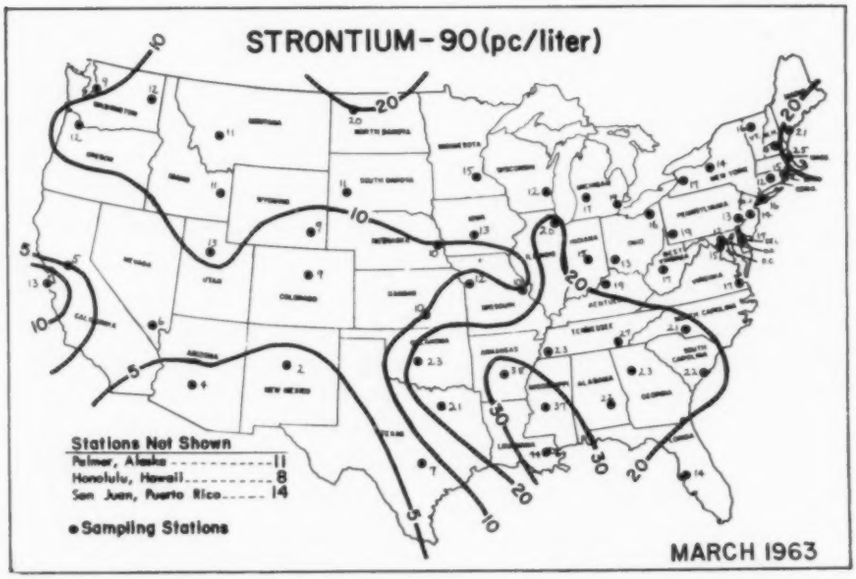

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

proportion to the plant's sales in the community served. At most of the stations, the composited sample represents 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in September 1961 and continuing through 1963, sampling was done twice a week at most stations, or daily for short periods at selected stations. Since then, sampling at most stations has been reduced to once a week.

All surveillance data are subject to continuing review and evaluation to observe unusual patterns or concentrations which may require immediate attention. Further atmospheric nuclear testing may require reevaluation and adjustment of the sampling frequency and schedule of analyses.

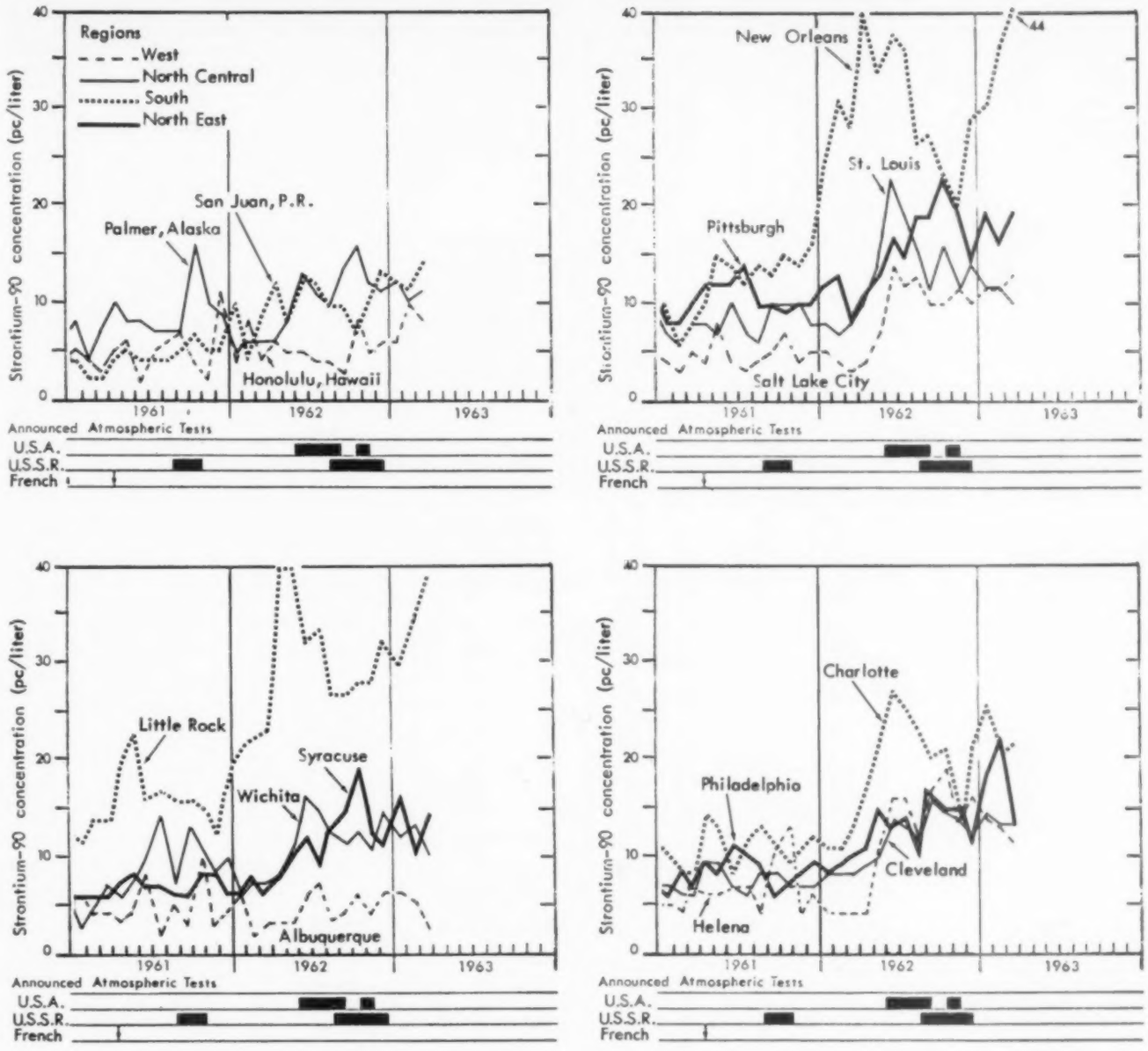

FIGURE 3.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

Analytical Errors

Iodine-131, cesium - 137, and barium - 140 concentrations are determined by gamma scintillation spectroscopy,[1] while strontium-90 concentrations are determined by radiochemical procedures. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation is relatively high. The variation is dependent upon the method of chemical analysis, the counting rate and counting time, the interferences from other radionuclides, and the background counting rate. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 minutes for low background beta determinations are used. Table 1 shows the approximate total laboratory analytical error associated with different radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentra-

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH TYPICAL CONCENTRATIONS OF SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)	Estimated concentration (pc/liter)	Error, ± 2σ (percent of concentration)
Iodine-131	10	± 100%	20	± 50%	100	± 10%
Barium-140	10	± 100%	20	± 50%	100	± 10%
Cesium-137	5	± 100%	10	± 50%	100	± 10%
Strontium-89	5	± 100%	10	± 50%	100	± 10%
Strontium-90	1	± 100%	2	± 50%	20	± 10%

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, MARCH 1963

(Average radioactivity concentrations in pc/liter)

Sampling locations		Calcium (g/liter)		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month	First quarter 1963	Avg. for month
Ala:	Montgomery	1.26	1.24	85	100	18	22	< 10	< 10	50	55	10	20
Alaska:	Palmer	1.19	1.14	20	20	11	11	< 10	< 10	65	50	10	< 10
Ariz:	Phoenix	1.20	1.12	20	20	4	4	< 10	< 10	20	20	< 10	< 10
Ark:	Little Rock	1.23	1.22	125	140	34	38	20	10	90	105	20	20
Calif:	Sacramento	1.23	1.19	25	50	4	5	10	< 10	30	35	10	< 10
	San Francisco	1.26	1.20	85	145	8	13	10	< 10	35	50	10	10
Colo:	Denver	1.29	1.26	15	20	11	9	20	20	65	55	< 10	< 10
Conn:	Hartford	1.11	1.12	< 5	< 5	12	12	< 10	< 10	65	60	< 10	< 10
Del:	Wilmington	1.13	1.14	5	< 5	17	17	< 10	< 10	70	70	< 10	< 10
D. C:	Washington	1.22	1.21	10	10	15	15	< 10	< 10	60	60	< 10	< 10
Fla:	Tampa	1.24	1.22	50	65	14	14	20	< 10	135	165	< 10	10
Ga:	Atlanta	1.24	1.22	100	110	21	23	10	< 10	85	90	20	20
Hawaii:	Honolulu	1.14	1.07	55	90	8	8	20	< 10	55	55	10	< 10
Idaho:	Idaho Falls	1.25	1.18	10	10	11	11	10	< 10	75	75	< 10	< 10
Ill:	Chicago	1.13	1.15	< 5	< 5	16	20	< 10	< 10	70	70	< 10	< 10
Ind:	Indianapolis	1.15	1.19	10	10	16	15	< 10	< 10	60	60	< 10	< 10
Iowa:	Des Moines	1.23	1.19	15	20	14	13	10	< 10	65	60	10	< 10
Kans:	Wichita	1.25	1.20	20	20	12	10	10	< 10	50	45	10	< 10
Ky:	Louisville	1.22	1.21	35	45	20	19	< 10	< 10	55	50	< 10	< 10
La:	New Orleans	1.27	1.25	265	365	37	44	20	10	120	155	30	40
Maine:	Portland	1.14	1.20	< 5	< 5	20	21	< 10	< 10	105	105	< 10	< 10
Md:	Baltimore	1.23	1.22	5	10	14	12	< 10	< 10	65	70	< 10	< 10
Mass:	Boston	1.14	1.16	< 5	< 5	19	25	< 10	< 10	95	95	< 10	< 10
Mich:	Detroit	1.16	1.17	< 5	< 5	18	19	< 10	< 10	75	75	< 10	< 10
	Grand Rapids	1.16	1.18	5	< 5	15	17	10	10	75	75	< 10	< 10
Minn:	Minneapolis	1.20	1.16	15	15	17	15	10	< 10	110	105	10	< 10
Miss:	Jackson	1.33	1.31	230	315	32	37	20	10	80	105	30	40
Mo:	Kansas City	1.12	1.19	25	30	14	12	< 10	< 10	50	45	10	< 10
	St. Louis	1.24	1.21	20	30	11	10	10	< 10	60	50	20	< 10
Mont:	Helena	1.18	1.04	20	20	13	11	10	< 10	90	80	20	< 10
Nebr:	Omaha	1.25	1.16	20	20	14	10	10	< 10	65	50	10	< 10
Nev:	Las Vegas	1.18	1.11	10	5	6	6	< 10	10	45	40	10	< 10
N.H:	Manchester	1.16	1.19	< 5	< 5	18	15	10	< 10	110	110	< 10	< 10
N.J:	Trenton	1.14	1.15	< 5	< 5	13	14	< 10	< 10	65	65	< 10	< 10
N.Mex:	Albuquerque	1.23	1.19	15	20	4	2	< 10	< 10	30	25	< 10	< 10
N.Y:	Buffalo	1.11	1.11	5	< 5	16	17	< 10	< 10	85	85	< 10	< 10
	New York	1.12	1.17	< 5	< 5	16	16	< 10	< 10	65	60	< 10	< 10
	Syracuse	1.12	1.17	< 5	< 5	13	14	< 10	10	65	65	< 10	< 10
N.C:	Charlotte	1.27	1.26	30	45	22	21	< 10	< 10	60	65	< 10	< 10
N.Dak:	Minot	1.21	1.19	15	25	23	20	< 10	10	85	80	20	< 10
Ohio:	Cincinnati	1.11	1.13	15	20	17	16	< 10	< 10	55	55	< 10	< 10
	Cleveland	1.12	1.09	< 5	< 5	14	13	< 10	< 10	60	65	< 10	< 10
Okla:	Oklahoma City	1.23	1.20	60	60	20	23	20	< 10	55	60	10	10
Ore:	Portland	1.25	1.22	55	55	11	12	< 10	< 10	70	65	20	< 10
Pa:	Philadelphia	1.13	1.17	5	< 5	18	13	< 10	< 10	65	60	< 10	< 10
	Pittsburgh	1.13	1.16	5	< 5	18	19	< 10	< 10	80	75	< 10	< 10
P.R:	San Juan	1.20	1.18	135	100	12	14	20	10	65	70	20	10
R.I:	Providence	1.13	1.16	5	< 5	16	15	< 10	< 10	75	80	< 10	< 10
S.C:	Charleston	1.26	1.24	105	110	23	22	20	10	80	90	20	20
S.Dak:	Rapid City	1.00	0.93	25	30	13	11	10	< 10	80	70	< 10	< 10
Tenn:	Chattanooga	1.29	1.25	75	115	23	27	< 10	< 10	65	75	10	20
	Memphis	1.26	1.22	100	130	23	23	10	< 10	50	60	20	20
Tex:	Austin	1.22	1.18	50	40	8	7	10	< 10	30	30	< 10	< 10
	Dallas	1.25	1.22	110	110	20	21	20	< 10	60	65	20	20
Utah:	Salt Lake City	1.26	1.21	15	15	12	13	10	10	100	90	10	< 10
Vt:	Burlington	1.11	1.10	< 5	< 5	16	16	< 10	< 10	85	80	< 10	< 10
Va:	Norfolk	1.25	1.23	30	35	17	17	< 10	< 10	65	65	< 10	< 10
Wash:	Seattle	1.24	1.19	30	30	10	9	10	< 10	75	60	10	< 10
	Spokane	1.31	1.25	15	20	12	12	10	< 10	85	70	10	< 10
W.Va:	Charleston	1.23	1.20	15	25	19	17	< 10	< 10	50	50	< 10	< 10
Wis:	Milwaukee	1.14	1.18	10	< 5	11	12	< 10	< 10	65	70	< 10	< 10
Wyo:	Laramie	1.24	1.20	20	25	12	9	< 10	< 10	95	80	20	10
	Network average	1.20	1.18	37	44	15.6	15.8	< 10	< 10	70	70	< 10	< 10

ion corresponds to a 95 percent certainty hat the true concentration is within this ange. The minimum detectable concentration s defined as that concentration at which the 2σ analytical error is 100 percent. Therefore, he minimum detectable concentration in nits of pc/liter are Sr^{89}, 5; Sr^{90}, 1; I^{131}, 10; Cs^{137}, 5; and Ba^{140}, 10.

Data Presentation

Table 2 presents summaries of all available analyses for March 1963, (February 24-March 30, 1963. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half of this value is used in calculating the monthly average. A similar procedure is used for the network average. Although no data are presented on the stable potassiuum concentrations in milk, analysis has indicated that the usual range of concentrations is from 1.4 to 1.7 grams/liter.

Figures 1 and 2 are isoconcentration maps showing the estimated radionuclide concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station.

Selected Monthly Strontium-90 Profiles

Continuing the practice followed in previous issues of RHD, figure 3 presents the average monthly strontium-90 concentrations in pasteurized milk from 16 additional cities in the sampling program. Each individual graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions.

INDIANA MILK NETWORK
April 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analyses in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 4).

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-lanthanum-140, strontium-89, and strontium-90. Analyses

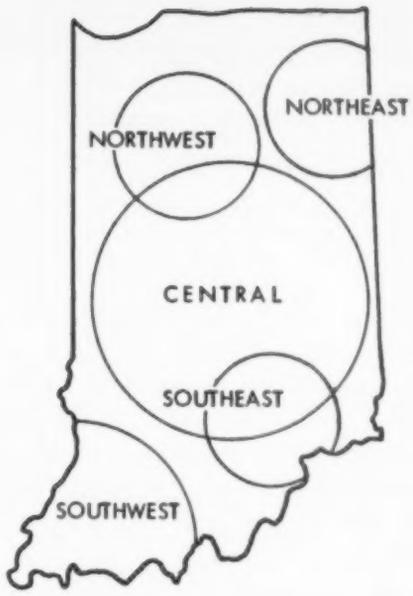

FIGURE 4.—INDIANA MILK SAMPLING LOCATIONS

for the gamma emitters iodine-131, cesium-137, and barium-lanthanum-140 are conducted on a weekly basis except when iodine-131 results exceed 100 pc/liter, at which time the frequency of sampling is increased. Strontium-89 and strontium-90 analyses are performed monthly on samples which are composited from weekly aliquots.

The ion exchange analytical procedure (*1*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodine crystal are used for the gamma analysis of iodine-131, cesium-137 and barium-lanthanum-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The average is an arithmetic average of the station values.

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, APRIL 1963
[Concentrations in pc/day]

Milkshed	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-lantha-num-140
Southwest	30	26	< 10	50	< 10
Northeast	< 10	17	< 10	65	< 10
Central	10	24	< 10	60	< 10
Northwest	35	19	< 10	70	< 10
Northeast	95	28	< 10	60	< 10
State average	35	23	< 10	60	< 10

REFERENCE

(*1*) Porter C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determinations of strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306-8 (September 1961).

CANADIAN MILK NETWORK [1]
February 1963

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

In January 1963, the Canadian Department of National Health and Welfare substituted the radioanalysis of fresh liquid milk for the analysis of powdered milk. The Department had analyzed milk powders from November 1955 through December 1962, but liquid whole milk had been monitored since April 1962 for iodine-131 only.

With this change, it has been possible to choose milk sampling locations in the same areas as the air and precipitation stations. This permits the observation of a number of environmental variables which may affect the radionuclide levels in milk. In addition, it is now possible to report radionuclide concentrations in terms of the activity per liter of milk as well as per gram of calcium in milk.

A detailed discussion of the sampling and radiochemical procedures employed for milk analyses may be found in the Department's publications (*1*, *2*). Table 4 presents the results of the measurements of strontium-89, strontium-90, cesium-137, and iodine-131 in Canadian liquid whole milk for February.

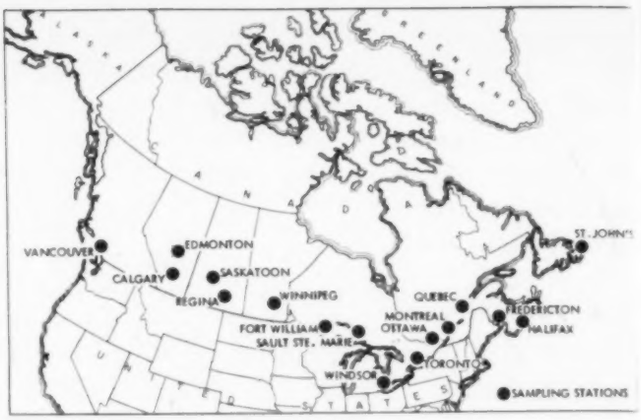

FIGURE 5.—CANADIAN MILK SAMPLING STATIONS, FEBRUARY 1963

It shoud be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the so-called Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (3), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average

[1] Data from *Data from Radiation Protection Programs*, Radiation Protection Division, Canadian Department of National Health and Welfare.

TABLE 4.—RADIONUCLIDES IN CANADIAN WHOLE MILK, FEBRUARY 1963

Station	Calcium (g/liter)	Strontium-89 (pc/liter)	Strontium-90 (pc/liter)	Iodine-131 (pc/liter) [a]	Cesium-137 (pc/liter)
Calgary	1.29	12	20.8	3	77
Edmonton	1.17	10	18.2	[b]—	63
Fort William	1.57	6	25.2	—	76
Fredericton	1.19	0	81.1	—	152
Halifax	1.25	5	27.0	1	59
Montreal	1.09	10	16.5	—	54
Ottawa	1.19	0	18.7	4	59
Quebec	1.17	0	23.9	4	97
Regina	1.19	3	16.1	—	26
Saint John's	1.19	6	20.9	—	70
Saskatoon	1.28	9	16.2	3	20
Sault Ste. Marie	1.23	0	14.0	1	43
Toronto	1.44	2	7.3	—	57
Vancouver	1.12	2	19.9	3	86
Windsor	1.32	0	12.3	6	32
Winnipeg	1.35	9	17.1	2	48
Average	1.25	5	19.1	3	63

[a] Each of the iodine-131 values is the average of nine samples.
[b] A dash indicates no sample.

evels over an extended period, such as one ear, represent a better basis for comparison han do individual levels at any specific time.

EFERENCES

(1) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurements of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1,* (July 1958).
(2) Mar, Peter G.: *Outline of Procedure for the Rariochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5,* Radiation Protection Division, Department of National Health and Welfare (June 1, 1960).
(3) Recommendation of the International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation,* Pergamon Press, New York (1959).

Twelve-Month Sum of Daily Radionuclide Content of One Liter of Pasteurized Milk

Iodine-131: May 1962—April 1963
Strontium-89 and Strontium-90: April 1962—March 1963

Division of Radiological Health,
Public Health Service

The guidance of the Federal Radiation Council (FRC) is given in terms of transient rates of intake of radioactive materials in micromicrocuries (or picocuries) per day. The action ranges proposed in FRC Report No. 2 are based on radiation doses considered acceptable for lifetime exposure from normal peacetime atomic industry operations (*1*). The Council recommends the use of a time period of one year as an appropriate interval for averaging exposures and emphasizes that the annual acceptable exposure dose is not a "danger point" which, if exceeded, requires protective measures (*1, 2, 3,*).

To facilitate comparison of the concentrations of certain radionuclides in milk with the Radiation Protection Guides, tables 1 and 2 furnish estimates of the contribution of milk to the total dietary intake of iodine-131, strontium 89, and strontium-90. The tables are developed from the PHS Pasteurized Milk Network monthly averages of the radionuclides. The index values are estimated sums of the daily amounts of a radionuclide in one liter of milk for a 12-month period.

The tables show 12-month index values for each of the Network's 62 sampling locations. Due to the longer time required for strontium-89 and strontium-90 analyses, these 12-month index values are for the year beginning one month earlier than the iodine-131 values. The columns of monthly index values in each table are used to compute the net change as the yearly index values are advanced by one month. The following column shows this new 12-month index value. In addition, the second column in table 1 gives the iodine-131 April 1963 concentration averages.

The data in tables 1 and 2 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the weekly averages for all weeks ending within a given month are averaged to obtain an average value for the month, and (c) the monthly radionuclide index value is determined by multiplying the monthly average by the number of days in the month. This number will be either 28 or 35, corresponding to the number of complete calendar weeks ending in a given month. Procedures exemplified by a and b above tend to minimize the effect of any one day's sample results on the average for the month, particularly for a short-lived radionuclide such as iodine-131. The yearly index values are obtained by the following procedure. Column (A) lists the twelve-month index values for the period indicated. Columns B and C, show the monthly index values for the periods indicated. The values in column (D) are obtained by adding the values in column (C) to those in column (A) and subtracting those in (B).

For a number of reasons it is desirable to use a standard quantity of milk in the develop-

TABLE 1.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF IODINE-131 IN ONE LITER OF MILK

(pc day/liter)

Station location		Apr. 1963 iodine-131 averages (pc/liter)	Iodine-131 index values [a]			
			Apr. 1962-Mar. 1963 (A)	Apr. 1962 (B)	Mar. 31, 1963-Apr. 27, 1963 (C)	May 1962-Apr. 1963 (D)
Ala:	Montgomery	< 10	6,590	140	140	6,590
Alaska:	Palmer	< 10	38,050	140	140	38,050
Ariz:	Phoenix	< 10	4,100	140	140	4,100
Ark:	Little Rock	< 10	14,840	140	140	14,840
Calif:	Sacramento	< 10	5,050	140	140	5,050
	San Francisco	< 10	4,770	280	140	4,630
Colo:	Denver	< 10	6,240	140	140	6,240
Conn.	Hartford	< 10	7,670	140	140	7,670
Del:	Wilmington	< 10	11,870	140	140	11,870
D. C:	Washington	< 10	8,440	140	140	8,440
Fla:	Tampa	< 10	6,660	140	140	6,660
Ga:	Atlanta	< 10	9,040	140	140	9,040
Hawaii:	Honolulu	< 10	4,730	140	140	4,730
Idaho:	Idaho Falls	< 10	9,070	140	140	9,070
Ill:	Chicago	< 10	13,690	140	140	13,690
Ind:	Indianapolis	< 10	12,010	140	140	12,010
Iowa:	Des Moines	< 10	21,670	140	140	21,670
Kans:	Wichita	< 10	21,740	140	140	21,740
Ky:	Louisville	< 10	10,540	140	140	10,540
La:	New Orleans	20	9,770	140	560	10,190
Maine:	Portland	< 10	8,160	140	140	8,160
Md:	Baltimore	< 10	8,690	140	140	8,690
Mass:	Boston	< 10	7,950	140	140	7,950
Mich:	Detroit	< 10	12,820	140	140	12,820
	Grand Rapids	< 10	9,730	140	140	9,730
Minn:	Minneapolis	< 10	15,650	140	140	15,650
Miss:	Jackson	< 10	9,700	140	140	9,700
Mo:	Kansas City	< 10	30,070	140	140	30,070
	St. Louis	< 10	12,360	140	140	12,360
Mont:	Helena	< 10	14,110	140	140	14,110
Nebr:	Omaha	< 10	19,220	140	140	19,220
Nev:	Las Vegas [b]	< 10	4,590	[c] —	140	4,730
N.H:	Manchester	< 10	7,710	140	140	7,710
N.J:	Trenton	< 10	7,990	140	140	7,990
N.Mex:	Albuquerque	< 10	6,520	280	140	6,380
N.Y:	Buffalo	< 10	8,720	140	140	8,720
	New York	< 10	11,660	140	140	11,660
	Syracuse	< 10	10,150	140	140	10,150
N.C:	Charlotte	< 10	3,370	140	140	3,370
N.Dak:	Minot	< 10	14,910	140	140	14,910
Ohio:	Cincinnati	< 10	14,600	140	140	14,600
	Cleveland	< 10	11,100	140	140	11,100
Okla:	Oklahoma City	< 10	18,380	140	140	18,380
Ore:	Portland	< 10	9,770	140	140	9,770
Pa:	Philadelphia	< 10	10,820	140	140	10,820
	Pittsburgh	< 10	14,810	140	140	14,810
P.R:	San Juan [d]	< 10	6,130	140	140	6,130
	Providence	< 10	8,580	140	140	8,580
S.C:	Charleston	< 10	7,180	140	140	7,180
S.Dak:	Rapid City	< 10	14,150	140	140	14,150
Tenn:	Chattanooga	< 10	7,850	140	140	7,850
	Memphis	< 10	10,050	140	140	10,050
Tex:	Austin	< 10	11,040	140	140	11,040
	Dallas	10	18,840	140	280	18,980
Utah:	Salt Lake City	< 10	31,920	140	140	31,920
Vt:	Burlington	< 10	8,380	140	140	8,380
Va:	Norfolk	< 10	6,410	140	140	6,410
Wash:	Seattle	< 10	9,770	140	140	9,770
	Spokane	< 10	21,390	140	140	21,390
W.Va.	Charleston	< 10	6,970	140	140	6,970
Wis:	Milwaukee	< 10	14,460	140	140	14,460
Wyo:	Laramie	< 10	19,540	140	140	19,540

[a] The data in this table are index values, not to be interpreted as consumption or total intake values. Annual iodine-131 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average individual daily milk consumption for any selected group under consideration.

Example: 12-month I^{131} index (pc day/liter) × milk consumption factor (liter/day/person) = 12-month I^{131} intake (pc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 9 and 10 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received in November 1962. The sums in columns A and D are therefore for 11 months.

TABLE 2.—TWELVE-MONTH SUM OF DAILY AMOUNTS OF STRONTIUM-89 AND STRONTIUM-90 IN ONE LITER OF MILK[a]

[pe day/liter]

Station location		Strontium-89 index values				Strontium-90 index values			
		Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)	Mar. 1962-Feb. 1963 (A)	Mar. 1962 (B)	Feb. 24, 1963-Mar. 30, 1963 (C)	Apr. 1962-Mar. 1963 (D)
Ala:	Montgomery	24,255	3,850	3,500	23,905	5,586	490	770	5,866
Alaska:	Palmer	19,375	90	700	19,985	3,920	210	385	4,095
Ariz:	Phoenix	6,600	875	700	6,425	1,176	105	140	1,211
Ark:	Little Rock	50,365	5,600	4,900	49,665	11,242	805	1,330	11,767
Calif:	Sacramento	7,195	1,225	1,750	7,720	1,421	140	175	1,456
	San Francisco	13,720	3,150	5,075	15,645	2,037	280	455	2,212
Colo:	Denver	10,310	90	700	10,920	3,899	175	315	4,039
Conn:	Hartford	8,140	90	90	8,140	3,983	245	420	4,158
Del:	Wilmington	13,195	350	90	12,935	5,173	315	595	5,453
D. C:	Washington	12,760	90	350	13,020	5,537	245	525	5,817
Fla:	Tampa	10,115	700	2,275	11,690	3,801	210	490	4,081
Ga:	Atlanta	29,680	4,550	3,850	28,980	6,804	490	805	7,119
Hawaii:	Honolulu	8,785	1,050	3,150	10,885	1,974	140	280	2,114
Idaho:	Idaho Falls	9,015	90	350	9,275	3,626	140	385	3,871
Ill:	Chicago	10,800	90	90	10,800	4,368	175	700	4,893
Ind:	Indianapolis	14,140	700	350	13,790	5,173	280	525	5,418
Iowa:	Des Moines	24,100	90	700	24,710	4,970	175	455	5,250
Kans:	Wichita	18,620	1,050	700	18,270	4,438	245	350	4,543
Ky:	Louisville	28,490	1,225	1,575	28,840	7,518	315	665	7,868
La:	New Orleans	55,510	11,025	12,775	57,260	11,186	980	1,540	11,746
Maine:	Portland	10,800	90	90	10,800	5,467	350	735	5,852
Md:	Baltimore	11,745	90	350	12,005	5,684	280	420	5,824
Mass:	Boston	11,430	90	90	11,430	6,132	350	875	6,657
Mich:	Detroit	9,855	90	90	9,855	4,578	210	665	5,033
	Grand Rapids	8,560	90	90	8,560	3,934	280	595	4,249
Minn:	Minneapolis	20,425	90	525	20,860	6,496	210	525	6,811
Miss:	Jackson	52,500	7,700	11,025	55,825	9,156	875	1,295	9,576
Mo:	Kansas City	31,080	700	1,050	31,430	5,600	245	420	5,775
	St. Louis	19,390	350	1,050	20,090	5,103	280	350	5,173
Mont:	Helena	16,870	175	700	17,395	4,739	140	385	4,984
Nebr:	Omaha	21,035	175	700	21,560	5,197	175	350	5,372
Nev:	Las Vegas[b]	5,600	[c] —	175	5,775	1,302	—	210	1,512
N.H:	Manchester	10,415	90	90	10,415	5,614	350	525	5,789
N.J:	Trenton	9,995	90	90	9,995	4,186	280	490	4,396
N. Mex:	Albuquerque	6,185	90	700	6,795	1,701	105	70	1,666
N.Y:	Buffalo	8,980	90	90	8,980	4,508	245	595	4,858
	New York	10,555	90	90	10,555	5,271	280	560	5,551
	Syracuse	9,625	175	90	9,540	4,284	210	490	4,564
N.C:	Charlotte	20,510	1,225	1,575	20,860	7,511	455	735	7,791
N. Dak:	Minot	16,865	90	875	17,650	7,686	280	700	8,106
Ohio:	Cincinnati	17,500	875	700	17,325	5,621	350	560	5,831
	Cleveland	10,730	90	90	10,730	4,606	280	455	4,781
Okla:	Oklahoma City	26,460	1,400	2,100	27,160	6,482	280	805	7,007
Ore:	Portland	31,045	700	1,925	32,270	5,082	245	420	5,257
Pa:	Philadelphia	10,415	90	90	10,415	5,145	350	455	5,250
	Pittsburgh	12,425	175	90	12,340	5,838	280	665	6,223
P.R:	San Juan[d]	26,005	3,150	3,500	26,355	3,591	315	490	3,766
R.I:	Providence	9,190	90	90	9,190	4,921	315	525	5,131
S.C:	Charleston	26,320	3,325	3,850	26,845	7,378	525	770	7,623
S. Dak:	Rapid City	20,355	90	1,050	21,315	5,908	210	385	6,083
Tenn:	Chattanooga	41,930	6,650	4,025	39,305	8,337	700	945	8,582
	Memphis	36,470	4,375	4,550	36,645	8,106	560	805	8,351
Tex:	Austin	11,935	1,050	1,400	12,285	2,814	245	245	2,814
	Dallas	31,255	2,800	3,850	32,305	5,817	350	735	6,202
Utah:	Salt Lake City	11,570	90	525	12,005	3,591	105	455	3,941
Vt:	Burlington	11,045	90	90	11,045	4,494	210	560	4,844
Va:	Norfolk	18,095	1,400	1,225	17,920	6,664	350	595	6,909
Wash:	Seattle	22,365	350	1,050	23,065	5,635	210	315	5,740
	Spokane	13,670	90	700	14,280	4,823	210	420	5,033
W. Va:	Charleston	21,070	350	875	21,595	7,133	280	595	7,448
Wis:	Milwaukee	8,665	90	90	8,665	3,304	175	420	3,549
Wyo:	Laramie	19,655	90	875	20,440	4,088	140	315	4,263

[a] The data in this table are index values not to be interpreted as consumption or total intake values. Annual strontium-89 or strontium-90 intake per person may be calculated from an index value in this table by applying the appropriate factor representing average daily milk consumption for any selected group under consideration.

Example: 12-month index value (pc/liter) × milk consumption factor (liter /day/person) = 12-month intake (pc/person)

[b] Station included in milk network in July 1962. The sums in columns A and D are therefore for 8 and 9 months, respectively.

[c] A dash indicates no analysis.

[d] No sample was received for November 1962. The sums in columns A and D are therefore for 11 months.

ment of index values for the radionuclides. When one is concerned with strontium, 1 liter is a suitable quantity, as this amount of milk supplies approximately 1 gram of calcium, the amount used by the Federal Radiation Council in deriving the intake guidance for strontium. When one is concerned with iodine-131, the critical age group is the young infant. Available information suggests that the average milk consumption of infants in the 6-18 month group is not more than 1 liter per day. Thus, the index value based on 1 liter of milk, though not directly an average intake value, is probably the most useful index for estimating tota intake.

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SECTION IV.—WATER

Radioactivity in Raw Surface Waters

NATIONAL WATER QUALITY NETWORK
January 1963

Division of Water Supply and Pollution Control, Public Health Service

Radioactivity levels in the surface waters of the United States have been included in the surveillance by the Public Health Service's National Water Quality Network since this nationwide sampling program was initiated in 1957. Beginning with the establishment of 50 sampling points, this network has been expanded as of May 1, 1963, to 126 stations (figure 1), which are operated jointly with State, Federal and local agencies and industry. The stations are located on the major waterways used for public water supplies, propagation of fish and wildlife, and recreational, agricultural, and industrial purposes. At these stations,

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, JANUARY 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS[a]

[Average concentrations in pc/liter]

Station	January 1963			
	Beta activity		Alpha Activity	
	Dissolved	Total	Dissolved	Total
Allegheny River: Pittsburgh, Pa.	21	30	0	0
Animas River: Cedar Hill, N. Mex.	30	37	8	9
Apalachicola River:				
Chattahoochie, Fla.	[b] —	—	—	—
Arkansas River				
Coolidge, Kans.	142	152	53	56
Ponca City, Okla.	32	52	12	13
Bear River: Preston, Idaho	25	30	2	2
Bighorn River: Hardin, Mont.	12	13	7	8
Big Sioux River				
Sioux Falls, S. Dak.	21	40	5	5
Chattahoochie River				
Atlanta, Ga.	—	—	—	—
Columbus, Ga.	15	37	0	0
Lanett, Ala.	22	83	0	7
Chena Slough: Fairbanks, Alaska	—	—	—	—
Clear Water River: Lewiston, Idaho	13	20	0	0
Clinch River				
Clinton, Tenn.	12	24	0	0
Kingston, Tenn.	1211	1316	1	2
Colorado River				
Loma, Colo.	34	78	13	20
Page, Ariz.	50	106	12	22
Boulder, City, Nev.	33	45	8	8
Parker Dam, Calif.-Ariz.	186	268	13	13
Yuma, Ariz.	26	38	13	13
Columbia River				
Northport, Wash.	13	20	1	1
Wenatchee, Wash.	23	27	0	0
Pasco, Wash.	473	524	1	1
McNary Dam, Ore.	294	322	1	1
Bonneville, Ore.	221	242	0	0
Clatskanie, Ore.	227	253	1	1
Connecticut River				
Wilder, Vt.	—	—	—	—
Northfield, Mass.	9	9	0	0
Enfield Dam, Conn.	23	36	< 1	< 1
Cuyahoga River: Cleveland, Ohio	39	45	< 1	1
Delaware River				
Martins Creek, Pa.	13	21	0	0
Trenton, N.J.	17	33	0	0
Philadelphia, Pa.	23	59	0	1
Great Lakes				
Duluth, Minn.	5	20	0	0
Sault Ste. Marie, Mich.	10	11	0	1
Milwaukee, Wis.	12	27	0	0
Gary, Ind.	13	15	0	1
Port Huron, Mich.	11	15	0	0
Detroit, Mich.	11	16	0	0
Buffalo, N.Y.	14	21	0	0
Green River: Dutch John, Utah	20	31	6	6
Hudson River: Poughkeepsie, N.Y.	22	22	0	0
Illinois River				
Peoria, Ill.	17	45	3	4
Grafton, Ill.	—	—	—	—
Kanawha River: Winfield Dam, W. Va.	11	14	0	0
Klamath River: Keno, Ore.	18	23	1	2
Little Miami River				
Cincinnati, Ohio	74	154	1	2
Merrimack River: Lowell, Mass.	34	50	0	0
Mississippi River				
St. Paul, Minn.	23	25	1	1
Dubuque, Iowa	19	22	3	4
Burlington, Iowa	18	23	0	0
E. St. Louis, Ill.	—	—	—	—
Cape Girardeau, Mo.	31	31	4	5
W. Memphis, Ark.	10	29	0	2
Delta, La.	18	44	0	1
Vicksburg, Miss.	34	62	1	4
New Orleans, La.	21	25	1	3
Missouri River				
Williston, N. Dak.	3	7	8	13
Bismarck, N. Dak.	13	15	0	0
Missouri River—con.:				
Yankton, S. Dak.	28	36	12	13
Omaha, Nebr.	23	24	3	3
St. Joseph, Mo.	26	26	6	6
Kansas City, Kans.	40	48	4	4
St. Louis, Mo.	40	66	7	11
Missouri City, Mo.	33	44	4	5
Monongahela River: Pittsburgh, Pa.	13	15	0	0
North Platte River: Henry, Nebr.	55	65	30	31
E. Liverpool, Ohio	15	15	0	0
Addison, Ohio	24	46	1	1
Huntington, W. Va.	24	32	0	0
Cincinnati, Ohio	16	35	0	0
Louisville, Ky.	20	45	0	2
Evansville, Ind.	12	53	0	2
Cairo, Ill.	20	82	1	12
Ouachita River: Bastrop, La.	37	58	1	2
Pend Oreille River				
Albeni Falls Dam, Idaho	19	31	< 1	1
Platte River: Plattsmouth, Nebr.	36	48	5	6
Potomac River				
Williamsport, Md.	—	—	—	—
Great Falls, Md.	17	63	0	1
Rainy River				
Baudette, Minn.	16	19	0	0
International Fls, Minn.	24	29	0	0
Red River: Grand Forks, N. Dak.	25	37	2	2
Red River, South				
Denison, Tex.	51	56	3	3
Index, Ark.	32	58	5	7
Alexandria, La.	30	73	0	2
Bossier City, La.	49	107	1	3
Rio Grande River				
Alamaso, Colo.	5	5	1	1
El Paso, Tex.	9	21	8	9
Laredo, Tex.	26	34	6	7
Brownsville, Tex.	17	26	5	6
Roanoke River				
John H. Kerr Resr. & Dam, Va.	13	24	0	0
Sabine River: Ruliff, Tex.	64	112	0	2
Sacramento River				
Greens Landing, Courtland, Calif.	9	21	1	1
San Joaquin River: Vernalis, Calif.	28	39	3	3
San Juan River: Shiprock, N. Mex.	48	73	8	8
St. Lawrence River: Massena, N.Y.	13	15	0	0
Schuylkill River: Philadelphia, Pa.	25	104	0	0
Savannah River				
North Augusta, Ga.	20	35	0	1
Port Wentworth, Ga.	36	54	0	0
Shenandoah River: Berryville, Va.	16	36	1	1
Ship Creek: Anchorage, Alaska	12	22	0	1
Snake River				
Ice Harbor Dam, Wash.	17	30	2	2
Wawawai, Wash.	15	16	3	3
Payette, Idaho	27	37	5	5
South Platte River: Julesburg, Colo.	90	109	38	40
Spokane River: Post Falls, Idaho	14	24	0	0
Susquehanna River				
Sayre, Pa.	15	21	0	0
Conowingo, Md.	16	24	0	0
Tennessee River				
Chattanooga, Tenn.	38	46	0	0
Bridgeport, Ala.	24	44	0	0
Pickwick Landing, Tenn.	39	53	0	0
Lenoir City, Tenn.	21	37	1	1
Tombigbee River: Columbus, Miss.	15	39	0	0
Truckee River: Farad, Calif.	5	5	0	0
Verdigris River: Nowata, Okla.	38	108	1	10
Wabash River: New Harmony, Ind.	40	68	1	1
Willamette River: Portland, Ore.	26	52	0	0
Yakima River: Richland, Wash.	12	20	< 1	< 1
Yellowstone River: Sidney, Mont.	16	23	3	3

[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data (7)*.

[b] Dashes indicate data not available.

amples are taken weekly, monthly, or continuously, depending on the type of analysis to be performed and on the water quality. These samples are then analyzed for plankton population, organic chemicals, radioactivity, and chemical, biological, and physical quality (*1*, *2*).

Radioactivity associated with dissolved solids provides a rough measure of levels which may be found in treated water, since nearly all of the suspended matter is removed by treatment processes (*3*). It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity whereas fallout contributes primarily additional beta activity. Gross alpha and beta measurements are made on both suspended and dissolved solids (strontium-90 on the total solids only) in raw surface water samples according to established procedures (*4*, *5*).

For the first two years of the network's operations, beta determinations were made on weekly samples, and alpha determinations were generally made on composites of more than one weekly sample. From January 1960 to September 1961, alpha and beta determinations were generally made once a month on weekly composited samples. Beginning in September 1961, alpha determinations have been made on one sample each month, and beta determinations have generally been made on weekly samples. For the first operating year of each new station, sampling, and alpha and beta analyses are done weekly.

It at any time activity significantly greater than the normal environmental levels has been noted, the rate of sampling and analysis has been increased to at least once every week. Since January 1959, a portion of each sample from all stations in the network has been composited into a three-month station sample for measurement of strontium-90 (*6*). Because strontium 90 analyses are done quarterly, the results will be published on this basis.

Table 1 presents the results of the alpha and beta analyses on raw surface waters in the United States for January 1963. These data are preliminary; reanalysis of some samples may be made and additional analyses, not completed at the time of the report, may become available. For final data one should consult the Network's *Annual Compilation of Data* (*7*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the total beta activity (pc/liter) in suspended-plus-dissolved solids in raw water collected at that station in January 1963.

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Radiostrontium in Tap Water[1]

July - December 1962

Health and Safety Laboratory U. S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 concentrations in tap water at New York City since August 1954 and at Richmond, California, since April 1958. Each sample analyzed is a monthly composite of daily samples. Also, determinations of strontium-89 have been made since September 1961 (*1*).

Data for the past several years are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report (*2*). Strontium-90 concentrations and strontium - 89/strontium-90 ratios for July through December 1962 appear in table 1.

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month	New York City[a]		Richmond, California[b]	
	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}
1959 Average	0.40		0.29	
1960 Average	0.47		0.26	
1961 Average	0.32		0.25	
1962 First quarter	0.51		0.27	
1962 Second quarter	0.60		0.23	
July [c]	0.88	3.0	0.14	2.9
August [c]	0.82	2.7	0.17	2.7
September [c]	1.05	1.8	0.18	1.4
October [c]	0.87	lost	0.28	3.6
November [c]	0.84	4.7	0.14	3.4
December [c]	0.82	3.9	0.30	3.4

[a] From 100-200 liters per sample.
[b] Approximately 100 liters per sample.
[c] Strontium-89 extrapolated to midpoint of sampling period.

Monthly average strontium - 90 concentrations in tap water at New York City reached a record high of 1.05 pc/liter in September 1962 but averaged between 0.8 and 0.9 during the last two quarters of 1962. Levels at Richmond, California have never been as high as those observed in New York, ranging between 0.14 and 0.35 pc/liter during 1962.

The strontium-89/strontium-90 ratios indicate that the fallout was probably not of any more recent origin when strontium-90 concentrations were high than when they were low.

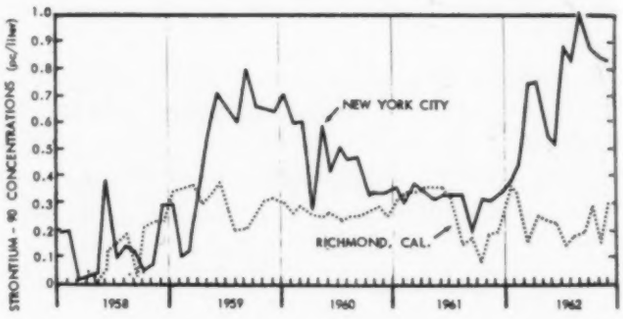

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

The maximum strontium-90 concentrations observed are well below the acceptable limit of 10 pc/liter as set forth in the interstate carrier drinking water standards (*3*).

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Recent coverage in *Radiological Health Data:*

Period	*Issue*
First quarter 1961	*December 1961*
Second quarter 1961	*March 1962*
Third and fourth quarters 1961	*June 1962*
January-April 1962	*September 1962*
March-June 1962	*January 1963*

[1] Data taken from *HASL-135* (*1*).

SECTION V.—OTHER DATA

Radiation Levels Aboard Commercial Jet Aircraft Resulting From Atmospheric Nuclear Weapons Tests

November 1961 - December 1962

Donald J. Nelson, Caleb B. Kincaid and Richard L. Mikkelsen

This report presents data and interpretation of radioactivity findings on commercial jet aircraft during periods of atmospheric nuclear weapons testing. Data presented were obtained through cooperative monitoring systems of the U. S. Public Health Service (PHS), the Federal Aviation Agency (FAA), and the airline industry through the Medical Committee of the Air Transport Association (ATA). The program is a continuation and expansion of cooperative activities with Pan American World Airways initiated in April 1959. The following data are reported for the period November 1961 through December 1962: film badge and pocket dosimeter measurements of external gamma radiation during commercial jet flights, determinations of gross beta activity and gamma emitters in cabin air, and surface radioactivity measurements by G-M survey meters and by filter paper swipes of contaminated aircraft surfaces.

The program monitored the following categories of flights originating in and returning to the United States: (a) *polar*, a flight going through or near the arctic region; (b) *equatorial*, a flight continuing near or along the equator; (c) *longitudinal*, a flight toward or across the equator and stopping at various Central and South American cities; (d) *latitudinal*, which includes transcontinental and European flights. Not all monitoring measurements were made on all flight categories; hence, the nature and extent of the measurements are described separately in each section.

External Gamma Radiation Levels

Dosimetry devices, consisting of film badges and pocket dosimeters provided by the Public Health Service, were placed in cockpits or baggage compartments on routine flights of jet aircraft. The dosimetric films exposed in flight and control films retained at the flight origin were returned to a commercial supplier for processing and reporting of exposures recorded.

The routes flown are indicated in figure 1. Air carriers whose flights were monitored for gamma radiation were: Pan American World

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Airways, Inc.; Pan-American-Grace Airways, Inc. (Panagra); Eastern Air Lines, Inc.; Trans World Airlines, Inc.; Northwest Airlines, Inc.; and United Airlines, Inc.

During the period from November 1961 through December 1962, a total of 725 film packs were exposed during flights, of which 700 indicated that the total gamma exposure in cockpits or baggage compartments was less than 10 mrem and twenty-five films indicated levels above 10 mrem, with the highest single exposure recorded being 640 mrem.

In the case of each exposure above 10 mrem, an investigation was made, revealing that in every instance the reported exposure was due to a source other than fallout debris. On such case was found to be due to a nonradia tion caused darkening of the film caused b excessive heat during the flight. Other fil exposures showing values in excess of 10 mre were traced to radioactive isotope shipment in the baggage compartment near the film pac These findings confirm previous estimates o limited external radiation exposure to passen gers and crews abroad commercial jet aircraf (*1*).

Cabin Air Radiation Levels

Previous studies (*1-5*) have shown tha minimum levels of airborne radioactivity are

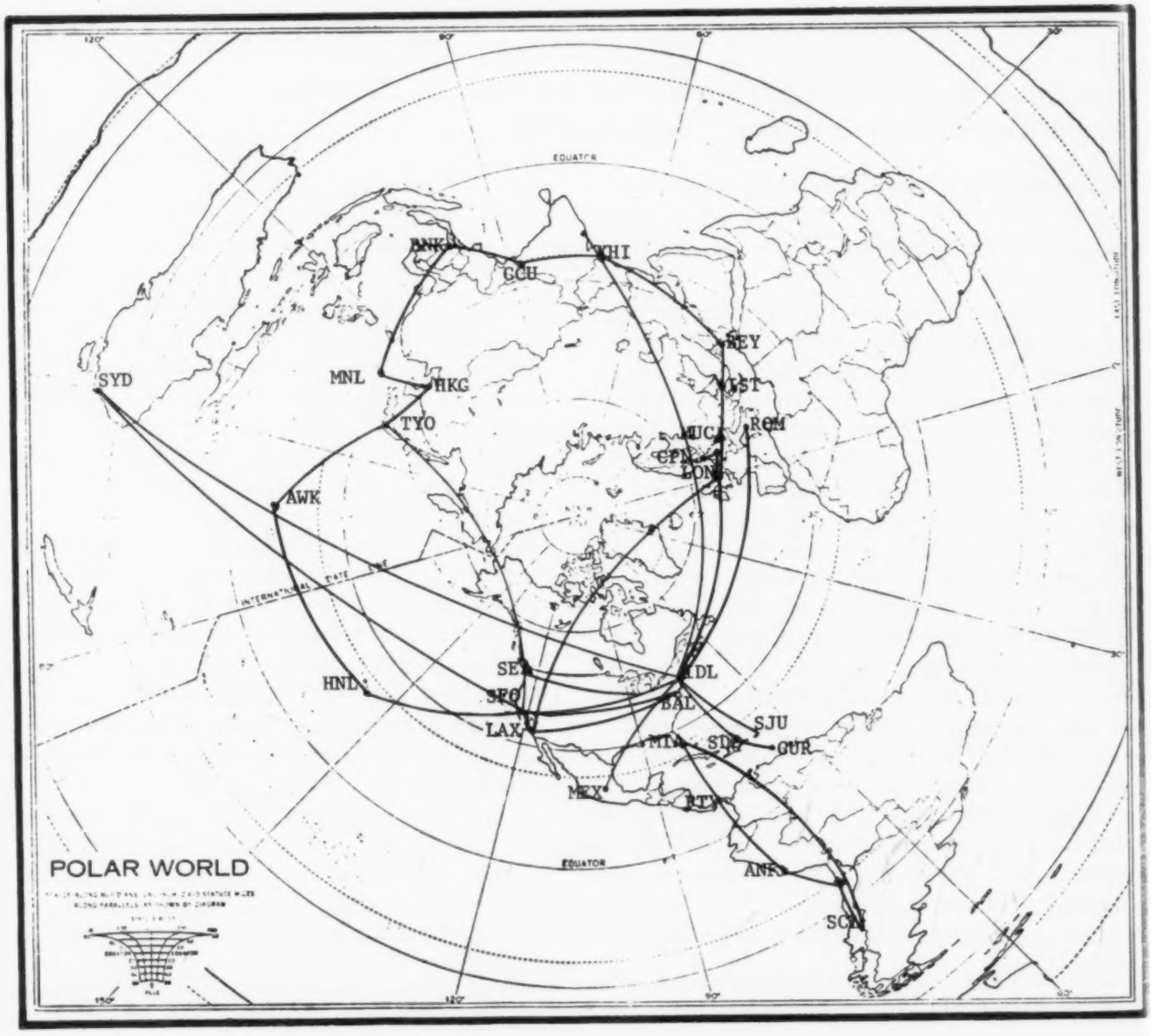

FIGURE 1.—AIRLINE ROUTES FLOWN WITH FILM BADGES ABOARD

ound in commercial aircraft over regular outes during weapons test operations. Restrictions of commercial air traffic in the icinity of test sites during operations have revented interception of fresh fission product louds. To make a further survey of cabin ir radioactivity levels, an air pump sampler with a membrane filter was carried aboard aircraft in transcontinental U. S. service. A portion of the intake air to the passenger compartment was passed through the membrane filter during flight. Filter paper samples were sent to the PHS laboratory at Rockville, Maryland, for gross beta determinations and scanning for identification of gamma emitters. Table 1 summarizes the results. The highest level of residual gross beta activity recorded was 270 pc/m^3. During the sampling period from February 25, 1962 to August 3, 1962, the higher beta activity levels were observed in the early spring months (range 2 to 270 pc/m^3) as compared to the later portion of the sampling period (range 0.66 to 19 pc/m^3).

TABLE 1.—LEVELS OF RESIDUAL GROSS BETA ACTIVITY IN AIR COLLECTED IN VENTILATION SYSTEM OF COMMERCIAL AIRCRAFT IN FLIGHT

Date 1962	Flight path [a]	Aircraft	Residual gross beta activity (pc/m^3) [b]
February 25	IDL to LAX	#N520	8.8
March 8	IDL to LAX	#N7520	130
April 22	IDL to LAX	#N512	91
April 27	LAX to IDL	#N512	75
May 3	IDL to LAX	#N520	65
May 6	IDL to LAX	#N517	56
May 10	LAX to IDL	#N520	270
May 10	IDL to LAX	#N520	2.9
May 13	LAX to IDL	#N512	29
May 22	LAX to IDL	#N512	24
May 26	LAX to IDL	#N512	36
May 31	IDL to LAX	#N512	2
May 28	LAX to IDL	#N520	3
May 28	IDL to LAX	#N7512	46
June 4	LAX to IDL	#N520	3.1
June 3	LAX to IDL	#N520	3.8
June 10	IDL to LAX	#N7520	1.9
June 10	IDL to LAX	#N512	8.9
June 10	LAX to IDL	#N520	2.1
June 17	IDL to LAX	#N7520	3.9
June 11	LAX to IDL	#N512	5.1
June 12	IDL to LAX	#N520	4
June 21	LAX to IDL	#N512	7.1
June 21	IDL to LAX	#N7520	2
June 28	IDL to LAX	#N520	1.2
July 1	LAX to IDL	#N520	0.88
June 28	LAX to IDL	#N520	0.66
July 2	IDL to LAX	#NB520	0.74
July 3	IDL to LAX	#N520	6
July 5	IDL to LAX	#N520	3.4
July 8	LAX to IDL	#N520	1.9
July 8	IDL to LAX	#N520	1.4
July 10	LAX to IDL	#N520	1.7
July 8	LAX to IDL	#N520	3.4
July 16	LAX to IDL	#N520	1.4
July 13	IDL to LAX	#N520	2.1
July 20	IDL to LAX	#N520	1.5
July 23	LAX to IDL	#N512	19
August 3	LAX to IDL	#N512	3.7

[a] IDL: Idlewild. LAX: Los Angeles.

[b] Sampling is by air pump with membrane filter operating aboard aircraft of American Airlines, Inc. with analyses performed by internal gas flow proportional counters at Radiological Health Laboratory, Public Health Service, Rockville, Maryland. Analyses are performed within five days of collection. Calibration standards are Sr^{90}-Y^{90}.

Aircraft Surface Surveys

The monitoring of aircraft surfaces for radioactive contamination by means of G-M type survey meters has been practiced by industry and government for years. Since 1959 the PHS has been receiving data from the airline industry for collation and evaluation. During the 1959-1961 moratorium on atmospheric weapons testing, surveys by the industry revealed a gradual decline of radioactive contamination levels on commercial jet aircraft in normal operation. With the resumption of atmospheric weapons testing in 1961, the PHS in cooperation with the Medical Committee of the ATA arranged for an expanded program of monitoring jet aircraft contamination. Radiation surveys were conducted by commercial airlines, and the findings of periodic inspections were sent to the Division of Radiological Health for evaluation and computation. Polar, equatorial and longitudinal flights were included in the survey. The aircraft which flew the polar and equatorial flights were Boeing 707 models; those which flew the longitudinal flights were generally Douglas DC-8 aircraft.

A survey of the entire surface of a craft would be exceedingly time consuming. On the basis of experience in previous aircraft surveys, it was concluded that significant contamination tended to be distributed where oil or grease collected and where there was a disturbance of air flow over the fuselage.

Because of differences in design of the two types of aircraft participating in the study, the areas selected for measurement of radioactivity were different. Figure 2 shows outlines of the B-707 and DC-8, and identifies the areas subjected to sampling and measuring of radioactivity.

The amount of radioactivity at the specified points was determined by using a G-M type survey meter—a THYAC Model 489-4 with a Victoreen 1B85 G-M tube, which can measure either beta and gamma fields or just gamma radiation. This type of meter is similar to the low range beta-gamma survey meter described by FAA (2). When the instrument window is open, both beta and gam-

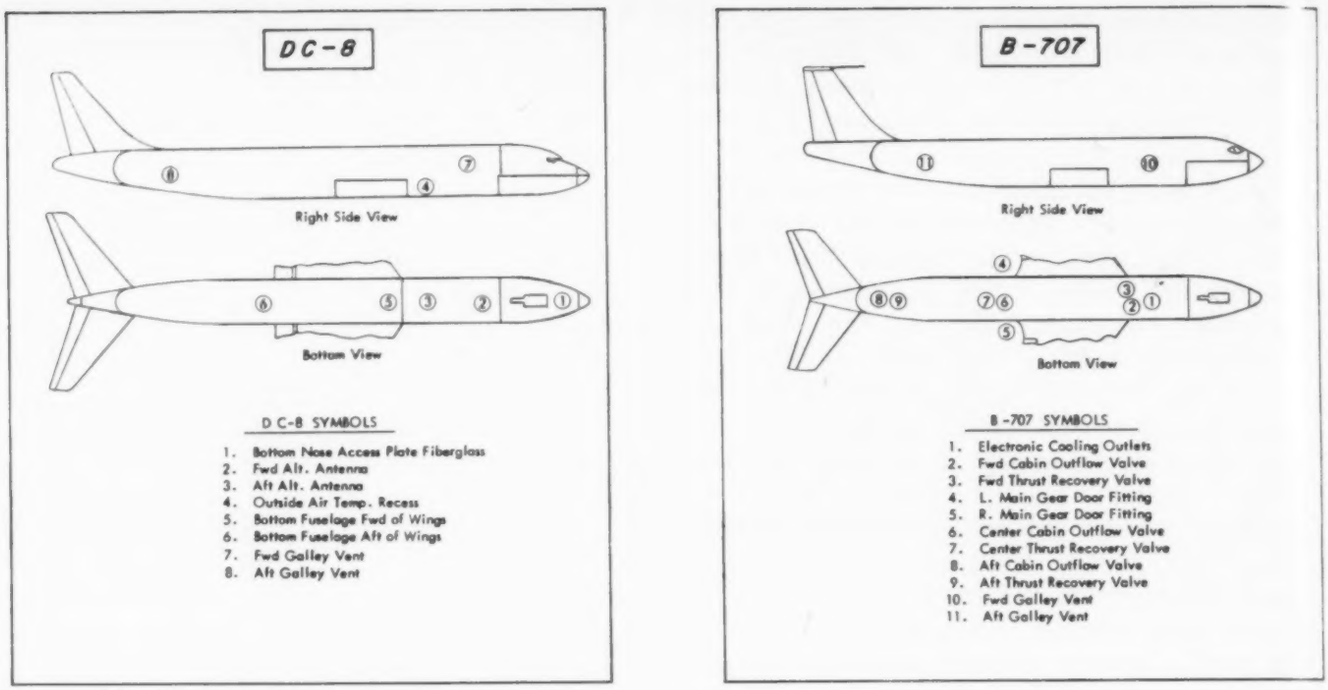

FIGURE 2.—DIAGRAMMATIC REPRESENTATION OF AREAS MONITORED

ma radiation field levels are recorded; when the window is closed, the beta activity is filtered out and only gamma levels are recorded. During readings, the instrument was held one inch from the surface of the aircraft to obtain standardized readings.

Alpha activity is not detected by this means; however, alpha contamination is not considered a controlling factor in exposure of personnel in or about the aircraft in commercial operation. Routine laboratory examinations of material wiped from the surface were made to assure that alpha contamination is not a problem.

After completion of a flight, the aircraft was monitored for surface radioactivity with the G-M survey meter. This measurement may or may not be cumulative from several flights because the planes were cleaned of radioactivity when the activity on any external portion of the plane produced a beta-gamma reading above 2.5 mr/hr. Detailed descriptions of various cleaning methods for different types of surfaces, and other related considerations, are included in the FAA Manual (*2*).

For the purposes of this study, it was considered necessary only to record the radioactivity on the basis of generalized flight routes and not to evaluate each individual flight. A detailed study would necessitate alteration of present techniques in order to either remove from consideration or evaluate adequately the numerous variables involved, such as: (1) variation in flight time; (2) variation in air speed and air currents; (3) variation in altitude of flight; and (4) variation in areas over which the craft flew. These variations exist for the flights classified under each generalized route; hence, the organization of flight data along general routes is justified for reasons dictated by practicality, and is necessary to provide a method of analysis and concise presentation.

Data sheets completed by representatives of the Association contained: survey instrument readings in counts per minute (cpm) and in mr/hr for each of the specified points on the aircraft; departure and arrival dates; readings; number of hours in flight; and cleaning operations. The background radiation at the place of measurement, determined before each set of readings, averaged 100 cpm or 0.025 mr/hr. The background radiation is included in the tabulated values.

Survey Meter Measurements—The daily aver-

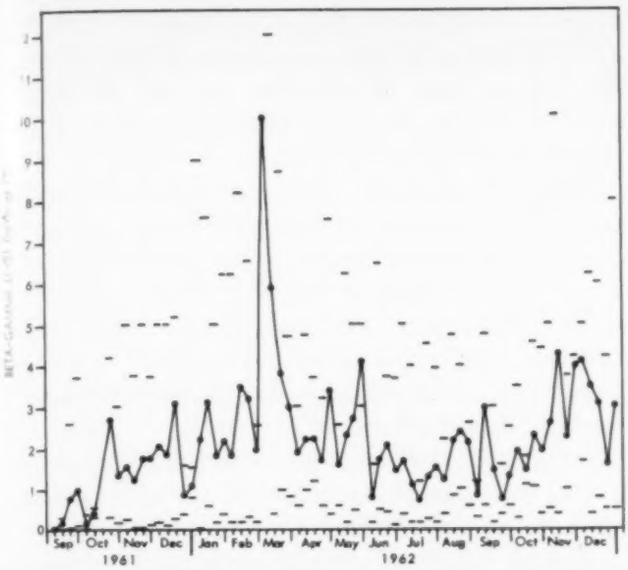

FIGURE 3.—WEEKLY HIGH, LOW, AND AVERAGE BETA-GAMMA LEVELS ON FORWARD THRUST RECOVERY VALVES ON BOEING 707 AIRCRAFT OVER LATITUDINAL, EQUATORIAL, AND POLAR ROUTES

age level of radioactivity was obtained by averaging the individual values recorded at the specified points on the aircraft. In several instances more than one daily average was obtained for a particular day. The daily average beta-gamma activity levels were plotted to present a visual picture of the variations in radionuclide concentration on the external surfaces of the aircraft. To show the variation in level of radioactivity at one representative point, the weekly average beta-gamma activity levels at the forward thrust recovery valve after each flight were plotted (figure 3).[2] The monthly average activity concentrations, derived by averaging daily average values during a monthly period, are shown in figure 4.

During the period of this study, at least three major nuclear weapons test series were announced, involving well over 100 tests by the U.S.S.R. and the United States at a number of test sites. Since fallout debris can remain in the atmosphere for long periods subject to dynamics of the upper and lower atmosphere, it would be extremely difficult or impossible to attribute any concentration of contamination on an aircraft surface to a particular test or series of tests. The variable in question is the time interval between a test and the recording of the resulting high concentrations aboard a particular aircraft. This variable can be eliminated to some extent when considering a series of high-yield nu-

[2] The beta-gamma values in figures 3, 4, 6, and 7 represent instrument readings, expressed in terms of mr/hr.

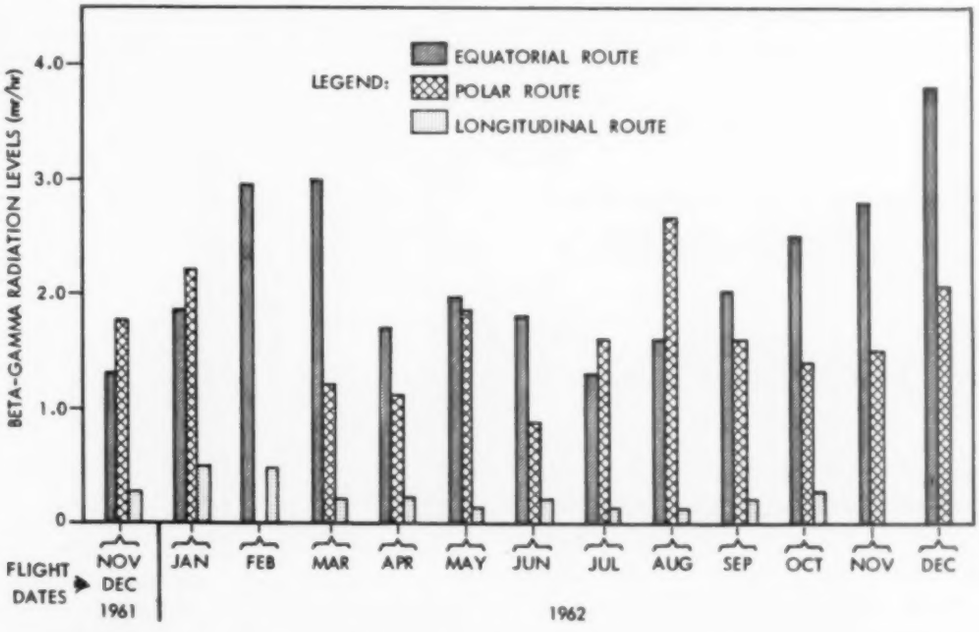

FIGURE 4.—MONTHLY AVERAGE LEVELS OF FISSION PRODUCT CONTAMINATION ON EXTERNAL SURFACES OF COMMERCIAL AIRCRAFT, FLOWN OVER EQUATORIAL, LONGITUDINAL, AND POLAR ROUTES

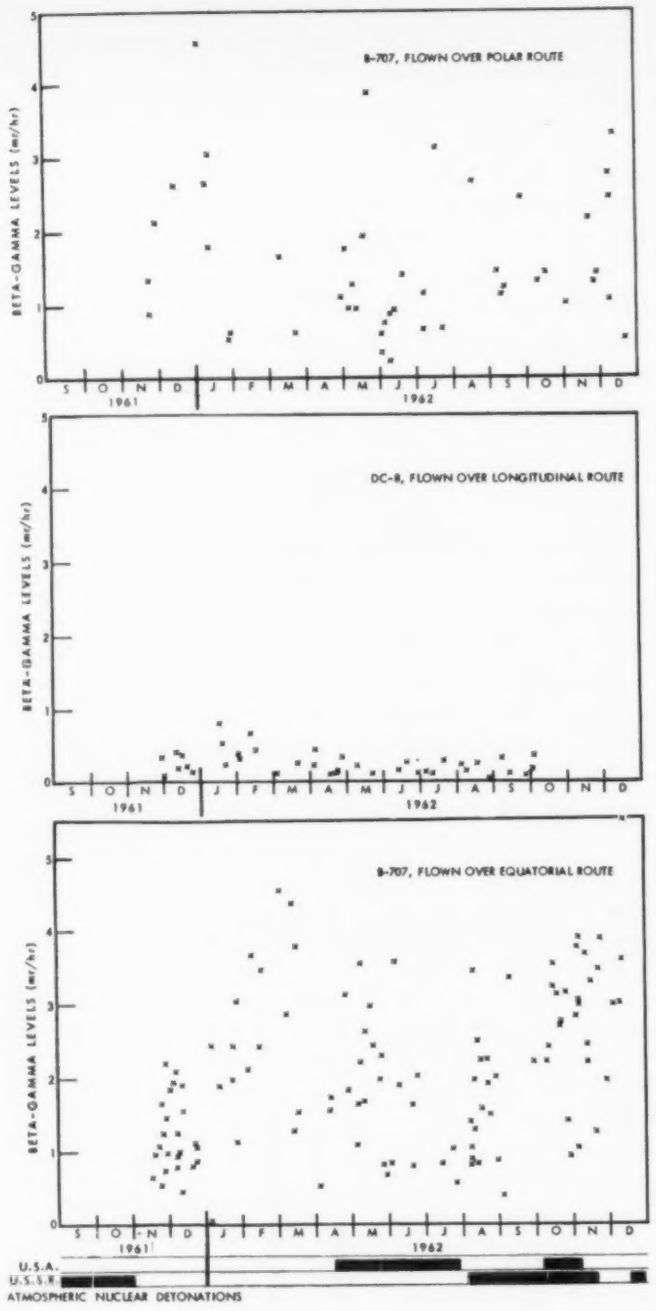

FIGURE 5.—BETA-GAMMA RADIATION FIELD MEASUREMENTS ONE INCH FROM EXTERNAL SURFACES OF COMMERCIAL AIRCRAFT

clear tests. An example of this may be the high peaks recorded on the polar route during December 1961 - January 1962 and those recorded on the equatorial route during February-March 1962. These peaks may represent the delayed effects of the extensive U.S.S.R. testing series during September to early November 1961; most of these detonations were in the high-yield range. The low levels of radioactivity recorded on the longitudinal route are attributable to the fact that most of the nuclear testing took place in the Northern Hemisphere.

Figure 5 plots the radiation levels measured near the surfaces of aircraft flying different routes, in terms of beta-gamma levels (mr/hr) at 1 inch distance from the surface, for the period November 1961-December 1962. For purposes of reference, a bar chart showing announced atmospheric detonations appears beneath figure 5.

Filter Paper Swipes—To establish the nature of the contamination collected on the aircraft surfaces during operation, a special sampling procedure was initiated to determine radionuclide composition. To obtain a sample for laboratory analysis, a two-inch diameter filter paper was used to wipe one square foot of the contaminated surface. The filter paper sample was counted by means of a laboratory gas-flow proportional beta counter calibrated by strontium-90 standards. Results were reported as gross beta activity in pc per 2-inch filter paper circle and were converted to pc/cm² by using

TABLE 2.—SUMMARY OF RESULTS OF SURVEY METER READINGS AND LABORATORY ANALYSIS OF FILTER PAPER SWIPE SAMPLE [a]

Survey meter results[b]			Beta activity in pc removed per cm² by 2 inch circle of filter paper[d]	Estimated percent removed by wiping
cpm	mr/hr $\beta-\gamma$	Total pc cm²[c]		
13,000	3.25	9,750	80	0.8
10,000	2.50	7,500	71	0.9
10,000	2.50	7,500	55	0.7
1,000	0.25	750	9	1.2
350	0.09	270	2	0.7
10,000	2.50	7,500	123	1.6
5,300	1.32	3,960	52	1.3
600	0.15	450	39	0.9
4,000	1.00	3,000	33	1.1
550	0.14	420	4	0.9
1,000	0.25	750	7	0.9
1,500	0.37	1,110	6	0.5
4,500	1.12	3,360	20	0.5
8,000	2.00	6,000	31	0.5
4,500	1.12	3,360	15	0.4
1,200	0.30	900	3	0.3
1,200	0.30	900	7	0.8
4,300	1.07	3,210	15	0.5
6,700	1.67	5,010	39	0.8
2,000	0.50	1,500	6	0.4
6,000	1.50	4,500	35	0.8
1,500	0.37	1,110	3	0.3
1,800	0.45	1,350	12	0.9
5,300	1.32	3,960	45	1.1

[a] From surfaces of commercial jet aircraft in operation out of Idlewild International Airport, Pan American Airways, October to December, 1961.

[b] As determined by aluminum wall Geiger-Mueller survey meter at one inch from contaminated surface.

[c] Using the conversion 1 mr/hr $\beta-\gamma \cong$ 3,000 pc/cm².

[d] As determined by analysis in gas flow proportional beta counter.

e simple conversion factor 930 cm^2/ft^2. Difficulties in obtaining an accurate sample of a square foot of surface prevented a reliable conversion to activity per unit area, but the estimates shown in table 2 indicate the degree to which activity was removed by this procedure.

Table 2 also shows readings made with an aluminum wall G-M survey meter at a distance of one inch from the aircraft surface sampled. The reading was obtained with the beta shield open and is expressed as counts per minute (cpm). The approximate conversion for the instrument used is 4,000 cpm per mr/hr. The results given are for the period October-December 1961. Additional tests made during 1962 indicate that the activity deposited on aircraft surfaces has shown no significant variation in terms of radionuclides significant to health. The activity consists of fission products whose radionuclide composition varies with the age of the sample.

The most abundant gamma-emitting radionuclides found were cerium-141, cerium-144, ruthenium-rhodium-103, ruthenium-rhodium-106, zirconium-niobium-95, barium-lanthanum-140, and iodine-131. No specific determination was made for pure beta emitters, but the gamma scan findings are consistent with those of fission-produced weapons test debris generally one year of age or less. This agrees with similar determinations previously reported by other investigators (*1-5*).

Gamma scans were performed during the monitoring of aircraft surfaces for beta-gamma activity. The values found ranged from 0.01 to 0.19 mr/hr (except for a single reading of 0.69). The ratio of gamma to total beta-gamma activity varied considerably; however, as is evident from the scatter chart (figure 6), the gamma activity tended to increase as higher beta activity occurred. In general, the lowest gamma to beta ratios were found on aircraft flown over an equatorial route, while the highest ratios were observed on aircraft flying over the longitudinal and polar routes, in that order.

Interim Operating Guidelines

The bases for establishing guides for handling procedures in connection with fission product contaminated aircraft surfaces and parts follow. They are generally consistent with guides reported previously (*1, 3*).

In addition, the FAA Manual (*2*) should be referred to for guidance in determining cleaning methods to be used on the various types of surfaces, clothing to be worn, procedures for handling and cleaning engine components, and personnel precautions to be taken in order to minimize exposure of aircraft personnel should hazardous levels occur as a result of nuclear warfare or other radiological emergencies. In general, they include assumptions that: (1) fission product contamination is one year of age or less, with strontium-90 con-

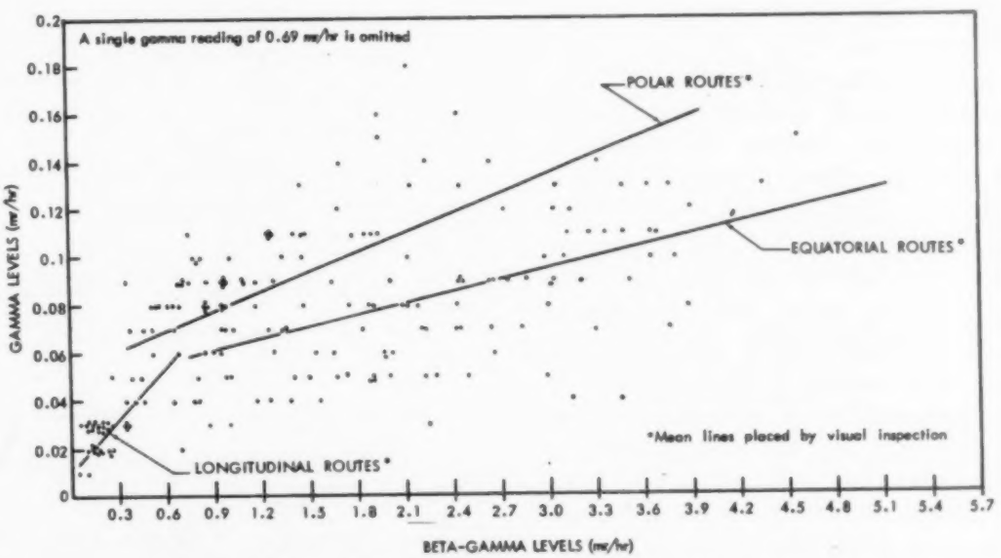

FIGURE 6.—RATIO OF GAMMA TO BETA-GAMMA LEVELS

tributing no more than 1 percent of the beta activity; (2) gamma field readings at 1 inch are not more than one-tenth the beta-gamma field readings at the same distance; (3) available contamination in terms of transfer to hands or gloves in ordinary handling is one-tenth the area contamination, and other routes of exposure such as inhalation are negligible; (4) not more than 50 percent of the material on hands or gloves is taken into the mouth as a result of eating or smoking; (5) the maximum surface contact time for hands during any week is 20 hours.

Previous investigations have indicated that with mixed fresh fission product (one year of age or less) debris on aircraft, the external radiation hazard is the principal factor and the inhalation and ingestion hazard may be ignored. This assumption is accepted in developing the exposure model, but only on the condition that proper precautions are taken with respect to personal hygiene in the handling of contaminated parts and surfaces. Nevertheless, a buildup of contamination levels may result in unique radiological situations in which a single ingestion may actually result in greater hazard to individuals than external gamma would produce.

The decontamination procedures referred to for air frames are those originally used in the commercial aircraft maintenance instructions, i.e., wet wash procedures including hosing and scrubbing with mops and detergents. Aircraft engines and parts receive a thorough cleaning during overhaul which is usually effective in removing contamination.

Although past experience indicates that aircraft radioactivity levels should not rise to hazardous proportions unless the aircraft penetrated a freshly formed cloud from a nuclear detonation, the PHS and the Medical Committee of the ATA drafted the foregoing operating guides for use by the airlines. The basic assumption was made that a reading from a properly calibrated G-M survey meter with aluminum wall detector, placed one inch from the contaminated surface, would give a meaningful indication of the contamination level. It was decided that if a nationwide program of monitoring all aircraft became necessary, the procedures for estimating contamination levels should be simple and operative at all locations where aircraft were berthed, maintained, or inspected. Figure 7 charts the minimal guidelines for suggested handling procedures.

With these assumptions, exposure values can be calculated for an aircraft surface showing a 20 mr/hr beta-gamma reading at one inch. The exposure from gamma radiation at a distance of one inch is assumed to be one-tenth of the total beta-gamma reading or 2 mr/hr. This would result in an annual external gamma exposure of 4.0 rem. The exposure value to the hands from beta radiation is calculated to be 20 mrem for each hour the hands are in contact with the contaminated surface.

Based on the above-mentioned assumptions it is possible that an individual could conceivably ingest up to 30 pc/day of strontium-90 for each cm^2 handled. To exceed the FRC Range II value for occupational exposure of 2,000 pc/day of strontium-90, the individual need only handle about 70 cm^2/day at the contamination level indicated. If the suggested "In Plant Handling Procedures" are followed, the ingestion of 2,000 pc of strontium-90/day becomes unlikely even though the individual handles many items or objects with beta-gamma readings of 20 mr/hr.

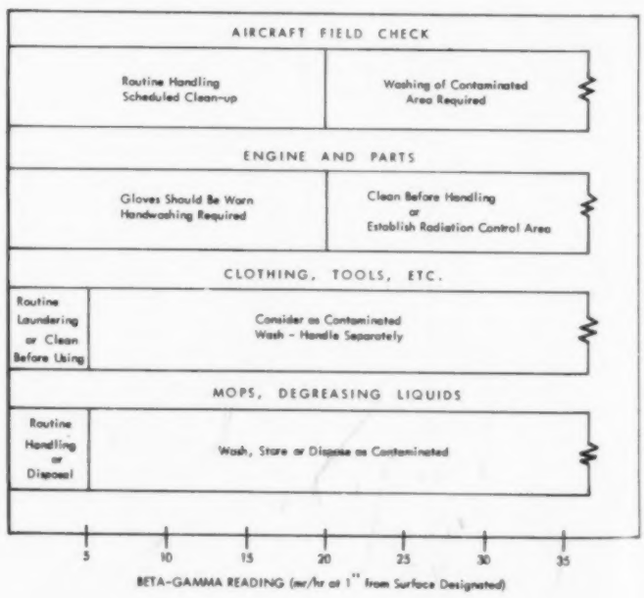

FIGURE 7.—MINIMAL SUGGESTED IN-PLANT HANDLING PROCEDURES FOR AIRCRAFT SUBJECTED TO FALLOUT

ummary

A review of the information obtained from adiological monitoring programs of the airne industry and the Public Health Service ndicates that the operation of U. S. commercial jet aircraft over national and international routes during the period of weapons esting, November 1961 to December 1962, has esulted in negligible radiation exposure to passengers and crews. Contamination of aircraft by fission products does occur. The characteristics of the deposition are the same as reported in previous studies.

None of the readings indicate that a radiation hazard existed either to personnel associated with the aircraft or to passengers. Also, potential hazards are very small during nuclear testing, provided that the suggested handling procedures are followed to prevent extensive radioactivity contamination buildup on the aircraft. Airlines are encouraged to adopt handling procedures, wherever possible, which would limit radiation exposure of personnel and to utilize the guidance of the Federal Radiation Council (FRC) and the International Commission of Radiation Protection (ICRP) for evaluation of specific radiation exposure situations.

Acknowledgments

The assistance and cooperation of the Air Transport Association of America in the pursuance of this study is gratefully acknowledged. Special credit is extended to Mr. H. Grady Gatlin, Secretary, Medical Committee, ATA; Dr. Otis B. Schreuder, Medical Director, Medical Committee, ATA, and to the other Medical Directors of this Committee; Dr. Charles Gullet, Dr. George J. Kidera, Dr. L. G. Lederer, Dr. John R. McGraw, and Dr. Robert B. Pender. In particular, acknowledgement is made to Mr. Ernest J. Vajda, of the Technical Operations Branch, DRH, for his technical assistance.

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Strontium-90 Content of Human Bone Specimens, 1960-1961[1]

P. G. Mar[2]

Introduction

The Radiation Protection Division's program for the determination of strontium-90 in human bone specimens was continued in 1961 in the same way as in preceding years. Post-mortem samples of vertebrae were collected through the cooperation of hospital pathologists in all the larger medical centers. A total of 634 samples have been received. However, over 70 percent of these were from subjects aged 40 years or more. Only a very few suitable samples of children's bones, which are of special importance in this study, were obtained.

Method

Except for a few minor adaptations, the method used for analysis of the bone samples was essentially the same as that for milk powder (*1*). The strontium-90 content was determined by adding stable strontium carrier, separating the strontium chemically, then determining the beta activity of the yttrium-90 daughter-product of the strontium. Calcium was determined by flame spectrophotometry. The results are reported as picocuries of strontium-90 per gram of bone calcium. The natural content of ordinary, non-radioactive strontium in the bone specimens was not estimated, and therefore no correction for this was made in the determination of the chemical recovery of the carrier.

Results

The results are given in table 1, classified into the same age classes as were used in previous years. However, for some of the classes only a very small number of samples is included and for these the "average" value is, of course, subject to a large probable error. A statistical analysis will be carried out when more data are available.

It will be seen that the average values for 1961 show only a very slight increase over the corresponding averages for 1960 (*2*).

Acknowledgments

The analytical work was carried out by J. Fenning, J. Quinn and C. Reynolds.

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Previous coverage in *Radiological Health Data:*

Period	*Issue*
1957 and 1958	*February 1961*
1960	*September 1962*

[1] Abstracted from Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP-5), Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada, December 1961.

[2] Dr. Mar is Radiochemist-in-Charge, Caldwell Avenue Laboratory, Radiation Protection Division, Ottawa, Ontario, Canada.

TABLE 1.—STRONTIUM-90 IN HUMAN BONE, 1960-1961

Age group	1960			1961		
	Number of subjects	Strontium-90 (pc/g Ca)		Number of subjects	Strontium-90 (pc/g Ca)	
		Average	Range		Average	Range
0- 1	117	1.52	0.77-3.71	1	2.11	
1- 5	8	1.58	0.65-3.31	5	1.99	0.58-3.38
6- 9	11	1.48	0.83-3.07	1	2.21	
10-19	24	1.41	0.59-2.75	5	1.79	0.88-2.31
20-29	15	0.96	0.39-1.52	12	1.08	0.40-1.77
30-59	65	0.92	0.38-1.97	49	1.01	0.49-3.04
Over 60	34	0.87	0.40-2.16	26	0.92	0.53-1.59

Strontium-90 in Canadian Soils, 1960-1961[1]

H. Taniguchi[2]

Introduction

In 1960, the Radiation Protection Division's radioactive fallout monitoring program was extended to include the assay of strontium-90 in undisturbed (non-agricultural) soils on an annual basis. These data were required to complement the information obtained through the monitoring of fallout in air and in precipitation (*1*). In some fallout studies, it is important to know not only the incremental amounts deposited on the ground in a given period, but also the total integrated amount from all the nuclear weapons testing carried out over the years. If a soil sample is obtained from a carefully selected site, the strontium-90 in it can be assumed to represent the total amount that has reached the ground at that location.

Sampling Sites and Method

Before the Radiation Protection Division's soil monitoring program was started, samples from selected Canadian sites had been taken by the U. S. Department of Agriculture and analyzed by the Health and Safety Laboratory of the Atomic Energy Commission (*2-5*) as part of a study of world-wide fallout patterns. The experience of the scientists engaged in this work was drawn upon in initiating the present program, particularly in the selection of suitable sampling sites.

Sampling was initiated at twenty-two of the stations across Canada at which monitoring is presently being carried out for radioactivity in air and precipitation.

The actual sampling sites at Montreal, Ottawa, Toronto, and Windsor were selected personally by Dr. L. T. Alexander of the U. S. Department of Agriculture, to emulate the choice of locations made in the U. S. program. The requirements for a suitable sampling site are: (a) the site should be nearly level, (b) the soil should have moderate to good permeability, (c) there should be little or no run-off during heavy rains, (d) there should be no over-wash at any time, (e) there should be no cropping or removal of vegetation, (f) there should be no dust from roads, and (g) the site should be located far enough away from buildings or trees which may affect the wind and precipitation pattern (*6*). The other sites were chosen with the advice of Dr. A. Leahey, Canada Department of Agriculture, to meet these requirements as closely as possible.

The samples were taken using a 3.5-inch diameter "cookie cutter" to cut through the turf to a depth of 2 inches. Sampling to a depth of 6 inches was then completed with a 3.25-inch diameter barrel orchard auger which cut a 3.5-inch diameter hole. Twenty individual cores were taken about a foot apart in a line and composited to give a sample representing 1.34 square feet (0.124 square meter). In subsequent years, the sample was taken in a line parallel to the previous year's, with a separation of about 3 feet between the lines.

Preparation of the Samples

The complete sample, as received, was dried in a forced circulation oven at 110° C. The sample (including stones) was then crushed with a laboratory crusher to a size suitable for passing through a pulverizer. The resulting fine powder was thoroughly blended using a laboratory blender. Aliquots from this homogeneous mix were taken for analysis.

The samples collected during 1960 (except in Halifax, Nova Scotia) were prepared for analysis at Beltsville, Maryland, by the U. S. Department of Agriculture. Aliquots of the prepared samples were obtained for analysis by the Radiation Protection Division.

Method of Analysis

The method of analysis followed closely that recommended by Hamada and Hardy

[1] Abstracted from Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW (RP-5), Radiation Protection Division, Department of National Health and Welfare, 370 Sparks Street, Ottawa, Ontario, Canada.

[2] Dr. Taniguchi is Radiochemist with the Radiation Protection Division of the Canadian Department of National Health and Welfare.

(7) in which, after the addition of stable strontium carrier the sample is leached with 6N hydrochloric acid. Alkaline earth oxalates are then precipitated from the leach solution. The oxalates are converted to nitrates and strontium is separated from the calcium by repeated precipitations with fuming nitric acid. This strontium is scavenged of barium, traces of lead and radium activities, until radiochemically pure. The amount of strontium-90 is then determined by separating, purifying, and counting its radioactive daughter, yttrium-90.

The efficiency of the 6N hydrochloric acid extraction of the strontium-90 may be expected to vary somewhat for different types of soil. For samples collected in the U. S. program during 1958, Hardy (*8*) has shown that the percentage of strontium-90 extracted varied from 71 to 97 percent. The average efficiency of the acid extraction of soils collected during 1969, covering a wide range of geographical locations and strontium-90 content, was 87 ± 8 percent, with a range of 78 to 101 percent (*9*). The present results, therefore, can be expected to be subject to an error of this order of magnitude.

It should be noted also that in calculating the results, the recovery of the strontium carrier was not corrected to take into account the natural strontium that may have been present in the soil. The presence of any natural strontium would make these uncorrected results low. The effect can be reduced by using a large amount of carrier; in the present work, 200 mg of strontium carrier were added to each 500 grams of soil analyzed. Despite this, there remains the doubt that some soils could have contained sufficient natural strontium to introduce an appreciable error. In future work, this uncertainty is to be resolved by the use of a tracer technique.

Results and Discussion

The results of the analyses for soils collected during the summers of 1960 and 1961 are presented in table 1, expressed as nanocuries of strontium-90 per square meter. No marked geographical differences are apparent except for the lower values at the more northerly stations. The national averages for 1960 and 1961 were, respectively, 15.8 and 15.4 nanocuries per square meter. Most of the stations are located between the 42nd and 60th latitudes. The average values in this zone were 17.2 and 16.9 millicuries per square kilometer in 1960 and 1961, respectively. Thus, within the limits of experimental error, there was no significant change from 1960 to 1961; the apparent decreases observed at some of the stations are smaller than the probable error.

In considering the experimental values, the inherent errors in the sampling and analysis should be kept in mind (*10*). The estimated error for similar analyses carried out elsewhere was reported to be from 8 to 13 percent (*11*). Each of the samples reported here was analyzed in duplicate or more, with an average reproducibility of about 10 percent.

The decreases noted at Ft. St. John, Fredericton, and Montreal, however, appear to be real, as the duplicate analyses agreed well. Whether this is due to a deeper penetration of the strontium-90 into the soil or to a transformation into a less extractable form can be determined only by further comparative studies. Studies of the vertical penetration of strontium-90 with time, as reported by Hardy (*12, 13*) indicate that between 25 and 33 percent of the total strontium-90 was below the top two inches and less than 6 percent was below the 6-inch level.

In view of the correction necessary for the natural strontium content of the soil and the

TABLE 1.—STRONTIUM-90 IN CANADIAN SOIL, 1960 AND 1961

Latitude	Longitude	Location	Strontium-90 (nc/m²)	
			1960	1961
Calgary	51.1° N	114.0° W	16.3	14.3
Edmonton	53.6° N	113.5° W	20.0	17.3
Ft. Churchill	58.8° N	94.1° W	15.4	16.8
Ft. St. John	56.2° N	120.7° W	13.2	7.0
Ft. William	48.4° N	89.3° W	23.5	23.7
Fredericton	45.9° N	66.5° W	17.4	8.9
Goose Bay	53.3° N	60.4° W	15.9	12.3
Halifax	44.6° N	63.8° W	11.9	23.7
Inuvik	68.3° N	133.5° W	3.9	3.3
Kapuskasing	49.4° N	82.5° W	17.3	14.8
Montreal	45.5° N	73.7° W	17.9	7.9
Moosonee	51.3° N	80.6° W	17.8	22.5
Ottawa	45.4° N	75.7° W	16.2	17.0
Regina	50.4° N	104.7° W	14.0	13.9
Saskatoon	52.2° N	106.7° W	16.1	14.4
Torbay	47.5° N	52.8° W	—	29.1
Toronto	43.6° N	79.4° W	17.4	16.3
Vancouver	49.2° N	123.2° W	24.8	24.8
Whitehorse	60.7° N	135.1° W	8.3	8.2
Windsor	42.3° N	83.0° W	18.5	19.6
Winnipeg	49.9° N	97.2° W	16.8	17.5
Yellowknife	62.5° N	114.4° W	8.8	6.2
National average			15.8	15.4
Average below 60° N latitude			17.2	16.9

mount of strontium-90 extractable by 6N ydrochloric acid, the values presented here ould be regarded as the lower limits of the tal deposition.

cknowledgments

The opportunity to observe and to discuss he soil analyses as carried out at the Health nd Safety Laboratory of the U. S. Atomic Energy Commission, granted by Dr. J. H. Harley, Laboratory Director, is gratefully acknowledged. Much advice and assistance were received from G. H. Hamada and E. P. Hardy, Jr. on the details of the analysis.

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The 1961 soil samples were taken by meteorologists of the Canada Department of Transport who are thanked for the cooperation and assistance given.

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Finally, the 1961 samples were prepared for analysis in the Radiation Protection Division by M. E. Lescot and the analyses reported here were performed by G. P. Cox, G. P. Dumouchel, and R. Tuszynski.

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Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Various summaries of the environmental radioactivity data for 22 AEC installations have appeared in *Radiological Health Data* since November 1960. Summaries follow for the Knolls Atomic Power Laboratory and the SIC Prototype Reactor Facility.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable values for continuous exposure given in the MPC's are one-tenth of the occupational MPC National Bureau of Standards "Handbook 69" (NCRP Report No. 22). The MPC values applicable to the reports that follow are given in table 1.

In these reports, nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low, a laboratory will assign an MPC value that is more restrictive than necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radioactive substance	Environmental MP s	
		Water (μμc/liter)	Air (μμc/m³)
1	Cerium-144	10,000	20
2	Cesium-137	20,000	50
3	Iodine-131	2,000	30
4	Plutonium-239	5,000	.06
5	Ruthenium-106	10,000	20
6	Strontium-89	10,000	1,000
7	Strontium-90	100	10
8	Zirconium-95	60,000	1,000
9	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[1]	3,000	—
10	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[1]	600	—
11	If Ra^{226}, Ra^{228} are not present[1]	100	—
12	Mixture of unidentified nuclides	10	0.04
13	If α emitters and Ac^{227} are not present[1]	—	1.0
14	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, and Pu^{241} are not present[1]	—	10
15	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present[1]	—	100

[1] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than 1/4.

KNOLLS ATOMIC POWER LABORATORY
Second Half 1961 and First Half 1962

General Electric Company
Schenectady, New York

The principal task of the Knolls Atomic Power Laboratory (KAPL) operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 1. The Knolls site occupies approximately 170 acres upon which are located administrative build-

TABLE 2.—AIRBORNE BETA ACTIVITY, KAPL
[Average concentrations in pc/m³]

Sampling locations	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Knolls site	1.3	5.2	4.7	4.3
West Milton site	2.2	4.4	7.0	6.8
Off-site	0.9	4.1	5.2	5.2

gs; chemistry, physics, metallurgical, engineering and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilites; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton and Bainbridge prototype reactors, equipment service building, fuel service building and waste treatment facility.

Air Monitoring

Environmental airborne radioactivity is measured at three locations on the Knolls site, four locations on the West Milton site and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. The results of the airborne radioactivity analyses are given in table 2. Measurements of airborne radioactivity are made at least 48 hours after collection to allow the naturally occurring short-lived materials to decay.

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated acording to the concentration of fission products in the collection tanks and the flow of the river. A continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principal component to be considered in control. The amounts and the radioisotopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 3. A total of 11.3 curies of beta activity were discharged to the Mohawk River during the four quarters.

Mohawk river water is sampled continuously at the General Electric Company Powerhouse eight miles upstream from the Knolls site, and the Vischer Ferry Powerhouse approximately two miles downstream. Samples taken from the City of Cohoes pumping station approximately thirteen miles downstream show the same concentrations obtained for the Vischer Ferry samples shown in table 4.

TABLE 3.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	Third quarter 1961	Fourth quarter 1961	First half 1962
Ce^{144}-Pr^{144}	1,000	37,000	19,000
Sr^{89}	560	8,000	19,000
Sr^{90}	850	15,000	8,100
Cs^{137}	1,700	31,000	27,000
Gross beta	4,700	100,000	74,000

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.012 curies were discharged to Glowegee Creek during the four quarters at an average concentration of about 400 pc/liter.

Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above and 2,640 feet below the point where the

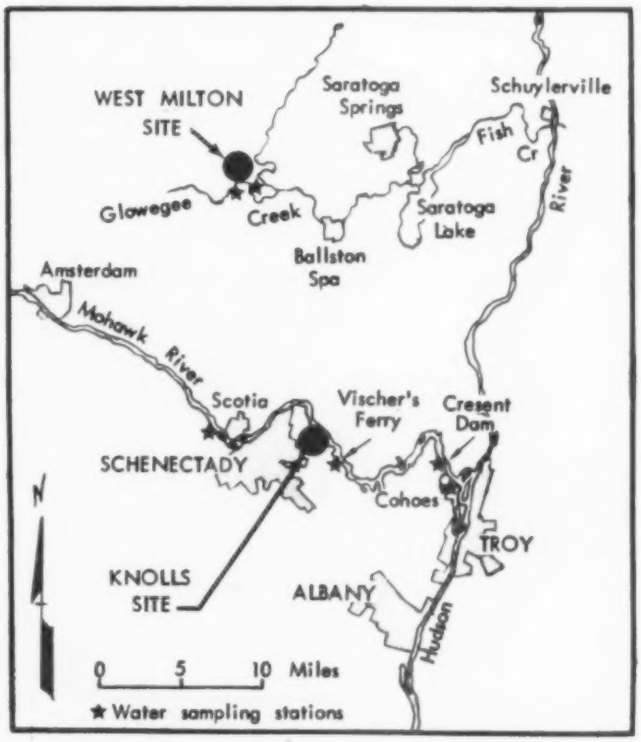

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL, 1961-1962

TABLE 4.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentrations in pc/liter]

Stream and location	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Mohawk River Knolls site:				
G. E. Powerhouse (upstream)	8	8	14	19
Vischer Ferry (downstream)	6	8	13	20
Glowegee Creek (West Milton site):				
Upstream	14	56	28	14
Downstream	8	38	25	11

West Milton site effluent enters the creek. Average concentrations found in samples of Glowegee Creek surface water are shown in table 4.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*

S1C PROTOTYPE REACTOR FACILITY
Second Half 1961 and First Half 1962

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development and training.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 5 and 6 give the average beta-

TABLE 5.— AIRBORNE BETA-GAMMA ACTIVITY, S1C

[Average concentrations in pc/m³]

Sampling location	Third quarter 1961	Fourth quarter 1961	First half 1962
Stack discharge	52	32	40
Downwind from stack	48	9.4	7.1

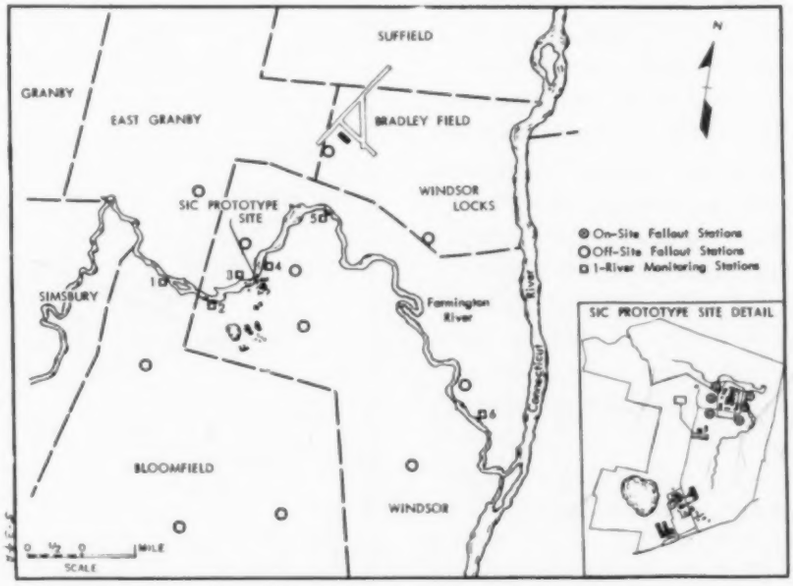

FIGURE 2.—ENVIRONMENTAL MONITORING LOCATIONS, S1C PROTOTYPE SITE, 1962

TABLE 6.—GROSS BETA RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C

Period/values	Third quarter 1961	Fourth quarter 1961	First quarter 1962	Second quarter 1962
Total for quarter	3.13 mc	9.55 mc	30.36 mc	15.60 mc
Average concentration	2,000 pc/liter	3,100 pc/liter	8,200 pc/liter	7,300 pc/liter

gamma concentrations of airborne and liquid wastes before release to the environment.

Figure 2 shows the locations of six water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data*. Comparisions of the data for upstream and downstream samples appear in table 7. Comparisons of on-site and off-site fallout samples appear in table 8.

TABLE 7.—BETA-GAMMA ACTIVITY IN THE FARMINGTON RIVER, S1C

[Average concentrations in pc/liter]

Sampling locations (see figure 2)		Third quarter 1961	Fourth quarter 1961	First half 1962
Upstream	1	1.5	66	37
	2	4.5	19	24
Outlet	3	120	17	18
Downstream	4	1.4	17	19
	5	2.7	22	18
	6	4.5	17	36

TABLE 8.—BETA ACTIVITY IN FALLOUT, S1C

[Average deposition in nc/m²/month]

Sampling locations	Third quarter 1961	Fourth quarter 1961	First half 1962
On site (6 stations)	3.29	37.2	33.0
Off site (11 stations)	3.68	40.4	34.7

Previous coverage in *Radiological Health Data:*

Period	*Issue*
First quarter 1960	*November 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and Second quarters 1961	*March 1962*

Reported Nuclear Detonations

June 1963

Four nuclear detonations in the United States during the month of June were announced by the Atomic Energy Commission. All tests were of low yield, conducted underground at the Nevada Test Site. Table 1 summarizes the detonations; the test numbers listed have been arbitrarily assigned by *RHD*.

On June 30, AEC announced evidence of possible recent U.S.S.R. nuclear tests of very low yield. The evidence being inconclusive, more definite conclusions cannot be made without further evidence and analysis.

TABLE 1.—SUMMARY OF NUCLEAR DETONATIONS REPORTED DURING JUNE 1963

Test number	Location	Date (1963)	Yield range	Type of test
104	Nevada Test Site	June 5	[a] Low	Underground
105	Nevada Test Site	June 6	Low	Underground
106	Nevada Test Site	June 14	Low	Underground
107	Nevada Test Site	June 25	Low	Underground

[a] Low yield range has been announced as less than 20 kilotons yield.

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UNITS AND EQUIVALENTS

Symbol	Name	Equivalent
Bev	billion electron volts	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc = 10^{-9} curies
nc/m^2	nanocurie per square meter	1 nc/m^2 = 1 $mμc/m^2$ = 1,000 $μμc/m^2$ = 1 mc/km^2 = 2.59 mc/mi^2
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr′ a
10^{9}	giga	G	jĭ′ ga
10^{6}	mega	M	mĕg′ a
10^{3}	kilo	k	kĭl′ o
10^{2}	hecto	h	hĕk′ to
10	deka	da	dĕk′ a
10^{-1}	deci	d	dĕs′ i
10^{-2}	centi	c	sĕn′ ti
10^{-3}	milli	m	mĭl′ i
10^{-6}	micro	μ	mī′ kro
10^{-9}	nano	n	nan′ o
10^{-12}	pico	p	pē′ co
10^{-15}	femto	f	fĕm′ to

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